WIRELESS ENGINEER

THE JOURNAL OF RADIO RESEARCH & PROGRESS

FEBRUARY 1953

VOL. 30 No. 2 THREE SHILLINGS AND SIXPENCE

	Vf	If	Ia (pk)	P.I.V. (max)
ESU 76	2.0V	7.5A	1.0A	10KV
ESU 200	4.0V	11.0A	5.0A	15KV
ESU 575	5.0V	11.0A	6.0A	15KV
ESU 866	2.5V	5.0A	1.0A	10KV
ESU 872	5.0V	7.5A	5.0A	10KV

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RADIATION COOLED

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ES 85 Vf-10V If-3-5A Va (max)-1.25KV Wa-85w μ-12.7 Ra-3,450Ω Maximum audio power output (per pair)-245 watts.

ES 833

ES833 Vf-10V If-10A Va (max)-4KV Wa-400w μ-35 Maximum audio power output (per pair)-2KW Maximum R.F. power output (single valve)-1.45KW Maximum frequency at full rating-30Mcs. At reduced ratings the frequency may be uprated to 75 Mcs.

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V1505 Vf-14V If-6.5A Va (max)-3KV Wa-275w μ-16 Ra-2,000Ω Maximum peak power output (per pair) on normal broadcast services-1KW.

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Left: Type 50-B 'VARIAC'

Right: Type 100-R 'VARIAC'

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Type	Load Rating	Input Voltage	Current		Output Voltage	No-Load Loss	Net Price £ s. d. *
			Rated	Maximum			
200-CM }	860 va.	115 v.	5 a.	7.5 a.	0-135 v.	15 watts	7 17 6
200-CU }							6 15 0
200-CMH }	580 va.	230 v.	2 a.	2.5 a.	0-270 v.	20 watts	9 15 0
200-CUH }		115 v.	0.5 a.	2.5 a.	0-270 v.	20 watts	8 5 9

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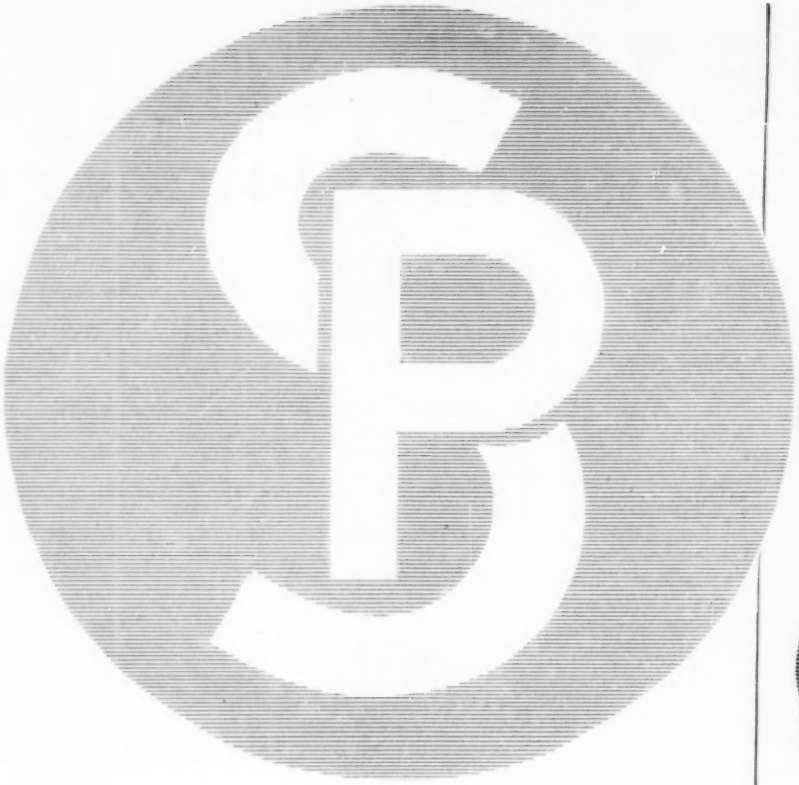

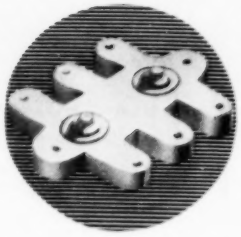

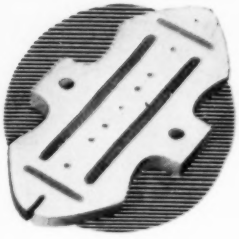

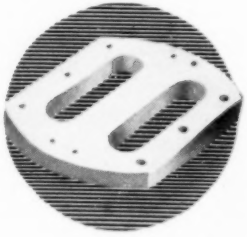

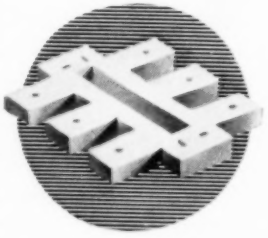

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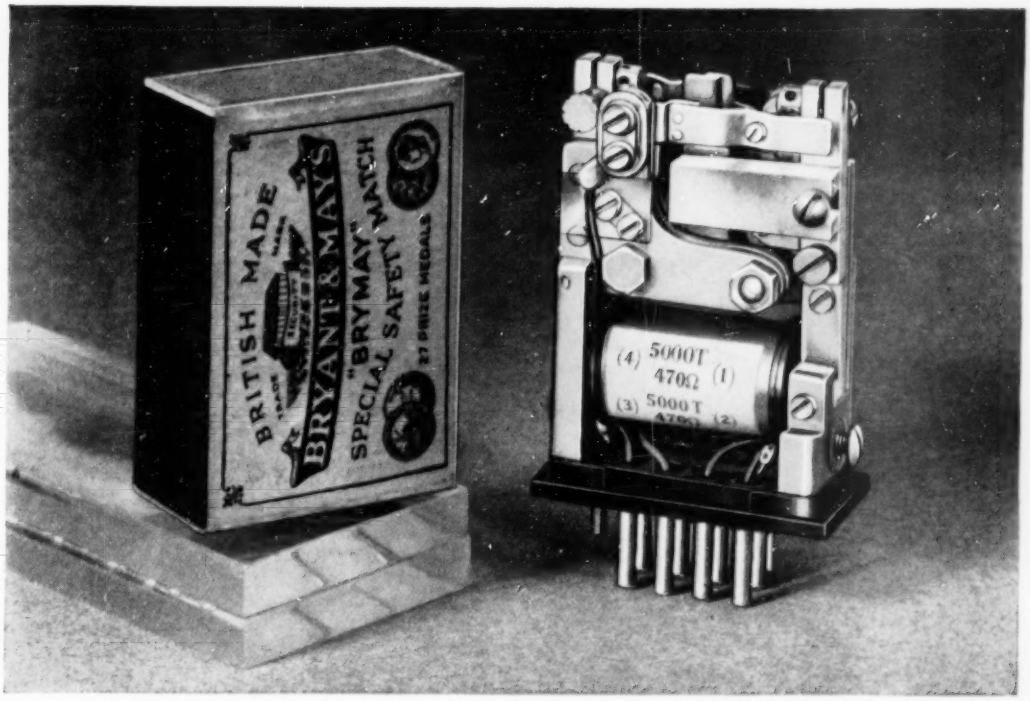

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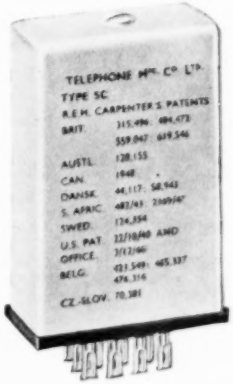

Plug or solder tag base optional.

Dimensions — (With cover. Excluding connecting pins.) $2\frac{5}{16}$ *ins. high.* $1\frac{7}{16}$ *ins. wide.* $\frac{3}{4}$ *in. deep. Weight (including socket)* 4.8 *oz.* (137 *gm.*)

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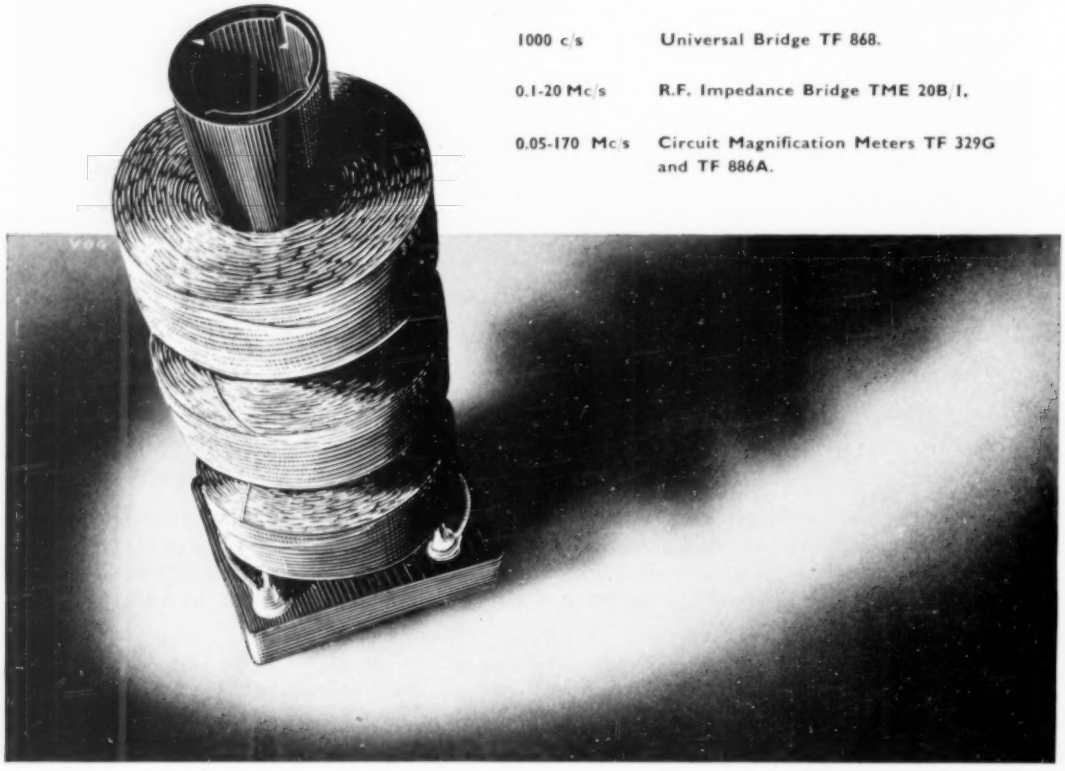

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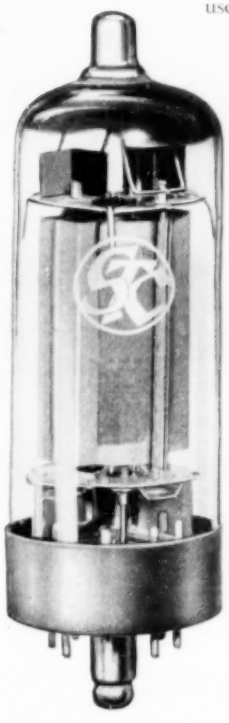

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5B/254M double-ended	5B/255M single-ended	5B/257M single-ended
6·3 V	6·3 V	12 V
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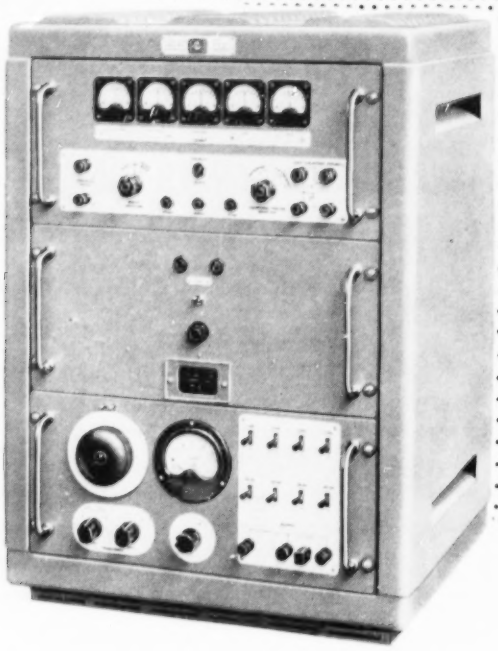

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The equipment will measure any frequency in the range 10c/s to 100kc/s and any time in the range 10μsec to 10^4sec both to an accuracy within ±0.005%. It will also count up to a maximum rate of 10^5 pulses/second.

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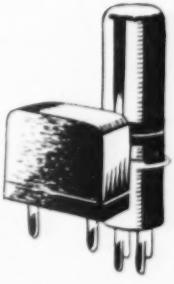

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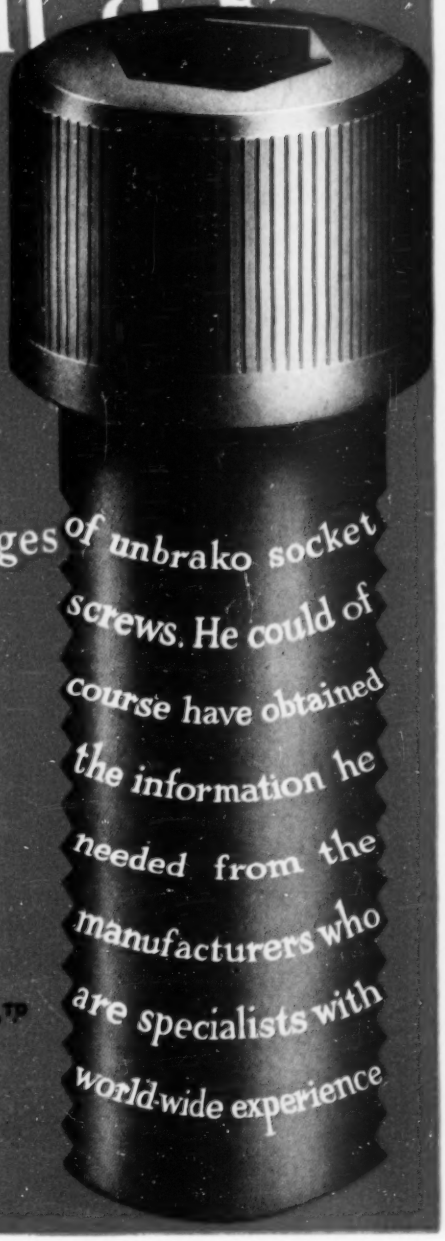

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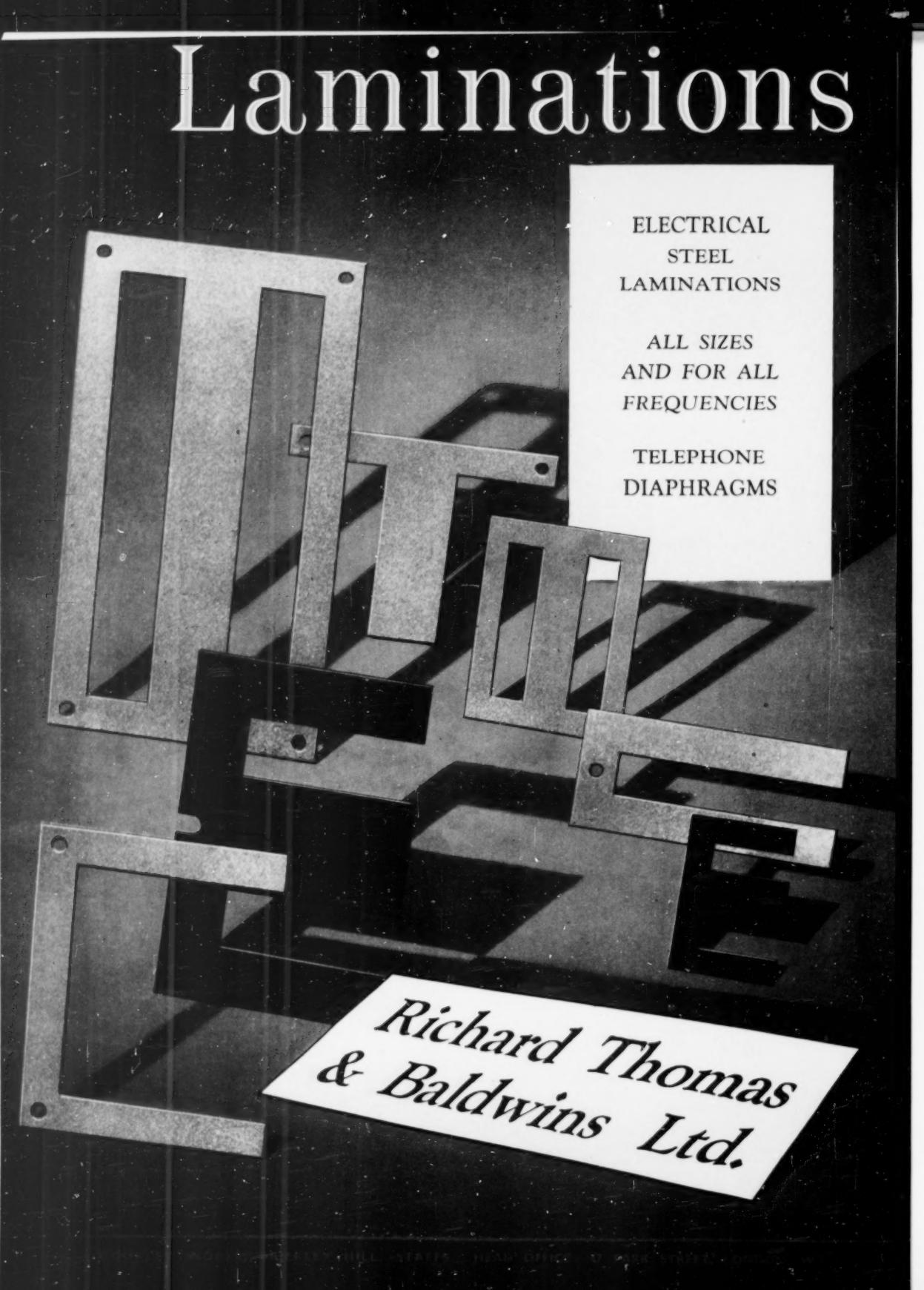

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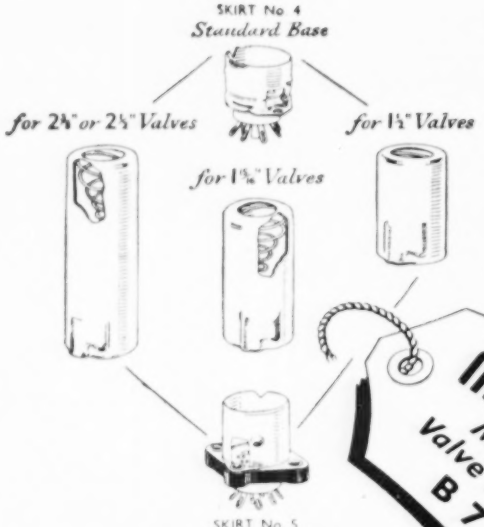

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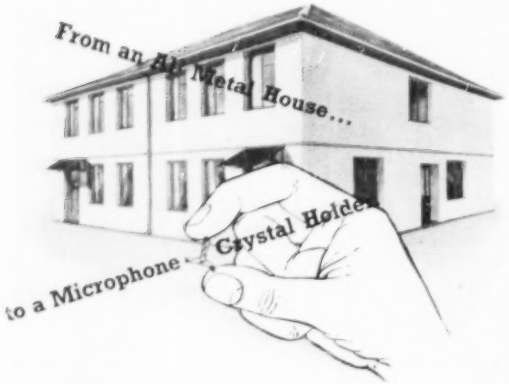

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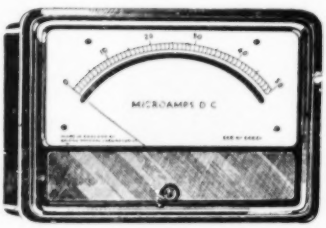

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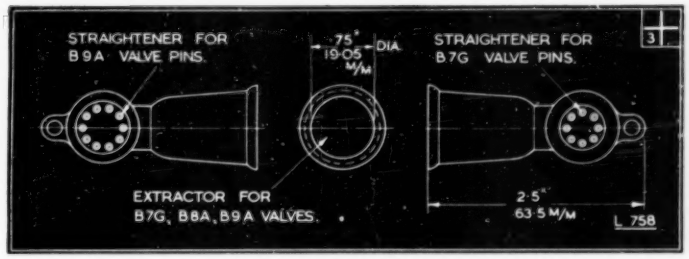
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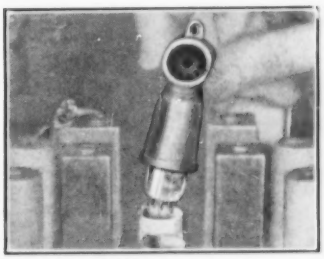
2·5" 63·5 M/M
L 758



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LIST NUMBER

L 758

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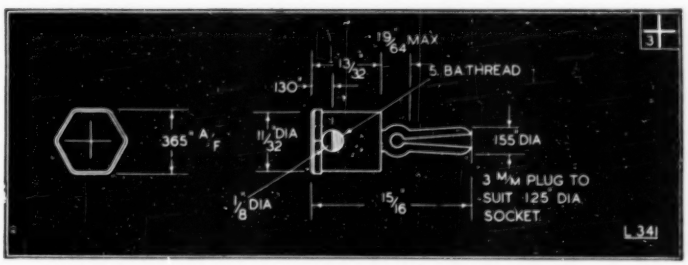

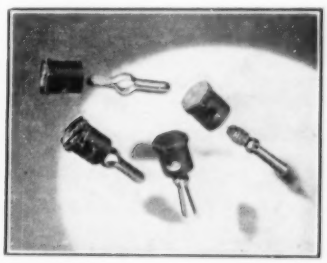

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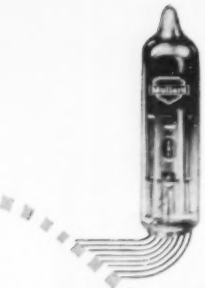
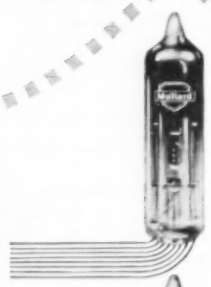
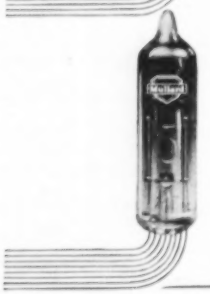


AVAILABLE SOON FOR COMMUNICATIONS AND INDUSTRIAL EQUIPMENT

indirectly-heated *subminiatures*





These new Mullard indirectly-heated subminiature valves, characterised by their extremely robust construction, excellent electrical performance, low heater consumption and small physical dimensions, will shortly be made available for communications and industrial equipment.

Developed originally for Service applications such as guided missiles and fire control systems, they will provide designers with types specially suited to all electronic applications where space is limited and where shock of impact or high g vibration is encountered.

The electrical performance of these subminiatures is equal to, and in certain cases even better than, that expected from valves of a much greater size. The EF72 R.F. amplifier, for example, which is suitable for use in the first stage of telecommunications receivers, combines many of the qualities of larger low-noise receiver input valves, with the ability to work at higher frequencies.

To enable experimental and development work to be carried out with these indirectly-heated subminiatures, a limited number of samples can be made available now. Designers who require further information are advised to send their enquiries to the address below as soon as possible.

Type No.	Description	Filament or Heater (V)	Filament or Heater (mA)	$V_a = V_{g2}$ (V)	$-V_{g1}$ (V)	I_a (mA)	I_{g2} (mA)	g_m (mA/V)
EA76	Single diode (5 mm. bulb)	6.3	150	150 (max.)	—	9.0 (max.)	—	—
EC70	U.H.F. triode oscillator	6.3	150	100	2.0	13	—	5.5
EF70	High slope R.F. pentode with short suppressor grid base	6.3	200	100	2.0	3.0	2.5	2.5
EF71	Variable-mu R.F. pentode	6.3	150	100	1.2	7.2	2.2	4.5
EF72	High slope R.F. pentode	6.3	150	100	1.4	7.0	2.2	5.0
EF73	High slope pentode for industrial applications	6.3	200	100	2.0	7.5	2.5	5.25
EY70	Half-wave rectifier	6.3	450	250 (max.)	—	45 (max.)	—	—
DY70	High voltage rectifier (directly heated)	1.25	140	10KV (P.I.V.)	—	2.0 (max.)	—	—

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WIRELESS ENGINEER

Vol. 30 FEBRUARY 1953 No. 2

The Geiger-Müller Counter

IT was in 1908 that Rutherford and Geiger succeeded in counting alpha particles (helium ions with a mass four times that of a hydrogen atom) by means of the discharge phenomena produced by them in an electronic tube; that is, a gas-filled tube containing two cold electrodes. A review of the subsequent development was recently published by Warmoltz in the *Philips Technical Review* of April 1952. As in the original type, the cathode is usually a cylinder and the anode an axial wire: the alpha particles enter the tube by means of a very thin mica window (in recent types 5 to 10 μ thick). The original tube was filled with carbon dioxide or air at a pressure of a few centimetres of mercury, and the p.d. between the electrodes was about 1,300 V.

On entering the tube an alpha particle collided with some of the gas molecules and ionized them; the charged particles then moved to the appropriate electrode, causing a current pulse in the external circuit which was registered on an electrometer. Nothing further happened until another alpha particle entered the tube, when another pulse was produced, and by counting these pulses one obtained a record of the number of alpha particles. To get more uniform results they tried replacing the cylindrical electrodes by a small ball at the centre of a hemispherical cathode, and to get the desired multiplication of ions with relatively low potentials, helium gas at a pressure of $\frac{1}{3}$ atmosphere was used. Although capable of counting alpha particles, these tubes were not sensitive enough to count beta or gamma radiation. To obtain greater sensitivity the cathode was made as a sharp point facing a flat anode, but the point was replaced by a small sphere, which could be reproduced more accurately; in 1928 Geiger and Müller reverted to the original cylindrical arrangement, the anode wire being strongly oxidized to facilitate quenching of the discharge.

Many experiments have been made with various types of gas filling. With a suitable gas filling and a steady stream of alpha particles, it is interesting to consider the effect of gradually increasing the applied voltage. With a very small voltage some of the ions produced by collision will recombine and thus never reach the electrodes; with the voltage above a certain value, recombination will not occur and all the electrons produced by the alpha particle will reach the electrodes; over this range the pulses will be of a constant amplitude. On further increasing the voltage, the ions will reach such a velocity that further ionization occurs in the tube, and the pulse amplitude will increase with the voltage. At a certain voltage the discharge would be self-sustained were it not for a suitable resistance in the circuit which causes such a drop of voltage that the discharge is quenched; sometimes the quenching is caused by a special circuit. These are the conditions under which the counters are usually operated; the sensitivity is sufficient to count beta or gamma radiation. There is an upper limit to the voltage that can be employed; beyond it the quenching fails and the discharge is maintained, but below this there is a wide range of voltage over which the counting is done with a high degree of accuracy, and the pulse amplitude increases with the voltage.

If the rate of arrival of the particles is very small the counter does not give an accurate record because, due to such causes as cosmic radiation, discharges occur even when no particles are arriving. To obtain an accurate result under these circumstances, a count should be made when no particles are arriving, and this background, as it is called, should be subtracted from the count obtained when the particles are arriving. The background can be reduced to about a half by enclosing the tube in a lead jacket about two inches thick. At the other end of the scale the counter fails if the particles follow each other too rapidly, for after each discharge a certain time must elapse before the tube regains its sensitivity and is able to respond to the following particle. The limitations imposed by these two phenomena are not very severe, for the former may be ignored if the rate of particle arrival exceeds about one per second, and the latter only comes into play if it exceeds about 10,000 per second.

The filling originally employed was air, carbon dioxide, hydrogen or nitrogen with the possible addition of some rare gas; as we have already mentioned, Rätherford and Geiger also tried helium at a pressure of a third of an atmosphere. In 1937 it was discovered that the quenching of a filling of hydrogen and argon was improved by the addition of ethyl alcohol or some such organic gas, but this has the disadvantage that it shortens the life and gives a variable sensitivity. About the same time the so-called halogen counters were introduced. It was found that the quenching of a tube containing neon with a small amount of argon was improved by the addition of a small quantity of chlorine or bromine; the life is unlimited provided that the materials employed in the tube are such as can withstand the destructive action of the halogen. It is often desirable that the counter should work at a relatively low voltage, and the addition of a small amount of rare gas makes this possible, 0·1% of argon lowering the disruptive voltage of neon to less than half; unfortunately it slows up the quenching, but the addition of a small amount of a halogen counteracts this without greatly increasing the necessary voltage. Satisfactory counters can be made with a working voltage of 250 V but, of course, they have their limitations.

The field of application of such counters is continually enlarging and the intensive research that is now being carried on will undoubtedly lead to further developments.

G. W. O. H.

INITIAL CONDITIONS IN TRANSIENT ANALYSIS

Replacement by Additional Sources of Energy

By L. Tasny-Tschiassny, Dr.Tech., M.I.E.Aust.

(Electrical Engineering Dept., University of Sydney, Sydney, Australia.)

Introduction

IF a linear network is initially at rest, it is customary to establish the network equations for the Laplace-Transform treatment of transients straight away, analogically to the usual steady-state analysis.[1,2] Instead of $(j\omega L)$ and $(j\omega C)$ we write (pL) and (pC) respectiyely; and for the e.m.fs of the voltage generators and the generated currents of the current generators the Laplace transforms of the respective time functions are substituted. The procedure in Heaviside's Operational Calculus is similar.

If the network is initially energized by charges in its capacitors and magnetic fluxes in its coils, the analogy is disturbed. Two ways of overcoming this difficulty have been described by G. W. Carter.[3] The present author has found that a statement made by A. Lee and D. K. C. MacDonald[4] regarding the equivalence of a charged capacitor and the series combination of an uncharged capacitor and a battery can be amplified and extended to magnetized coils, and leads to a very simple method of dealing with initial conditions. The following two theorems and examples explain the method in detail.

MS accepted by the Editor, April 1952

2. Theorems

Theorem I (*For Charged Capacitors*). A charged lossless capacitor is equivalent to the series combination of the uncharged capacitor and a battery that generates the voltage to which the capacitor is charged. An alternative is the parallel combination of the uncharged capacitor and a current generator that generates at zero time a current pulse conveying the initial charge of the capacitor. Dielectric losses

are to be considered as a resistance connected in parallel to the combinations.

Fig. 1 explains the theorem. The symbol $\delta(t)$ stands for the impulsive function;[5] i.e., a function of time which becomes infinite within an infinitely short time interval and falls back to zero within another infinitely short time interval in such a way that $\int_0^t \delta(t)dt = 1$ for any finite time t. The dimension of $\delta(t)$ is (time)$^{-1}$, its Laplace transform unity, and, as far as linear networks are concerned, we work with $\delta(t)$ as with analytical functions.

Fig. 1. *Equivalent circuits of a charged capacitor for which E is the initial voltage, Q is the initial charge, and i(t) is the equivalent current pulse.*

Theorem 2 (For Magnetized Coils). Each coil in an arrangement of lossless coils that are linked by individual and mutual magnetic paths, in which magnetic fluxes produced by initial coil currents are established, is equivalent to the parallel combination of the currentless coil and a current generator generating a constant unidirectional current equal to the initial coil current. An alternative, admissible when all coils are treated in this way, is the series combination of the currentless coil and a voltage generator that generates at zero time a voltage pulse conveying a number of volt-seconds numerically equal to the total initial flux linkage of the coil. The ohmic resistances of the coil windings are to be considered as resistances, connected in series with the combinations.

Fig. 2 explains the theorem. For one coil only, Theorem 2 becomes the dual of Theorem 1. If, by a switching procedure carried out at zero time, the initial currents in the coils are changed without a change in the magnetic fluxes, the coil currents prior to switching can be used for Theorem 2. The step-changes in the currents caused by the switching appear automatically in the results.

3. Proof of the Theorems

To prove the theorems, assume the total currents between the terminals AB, CD, EF, GH

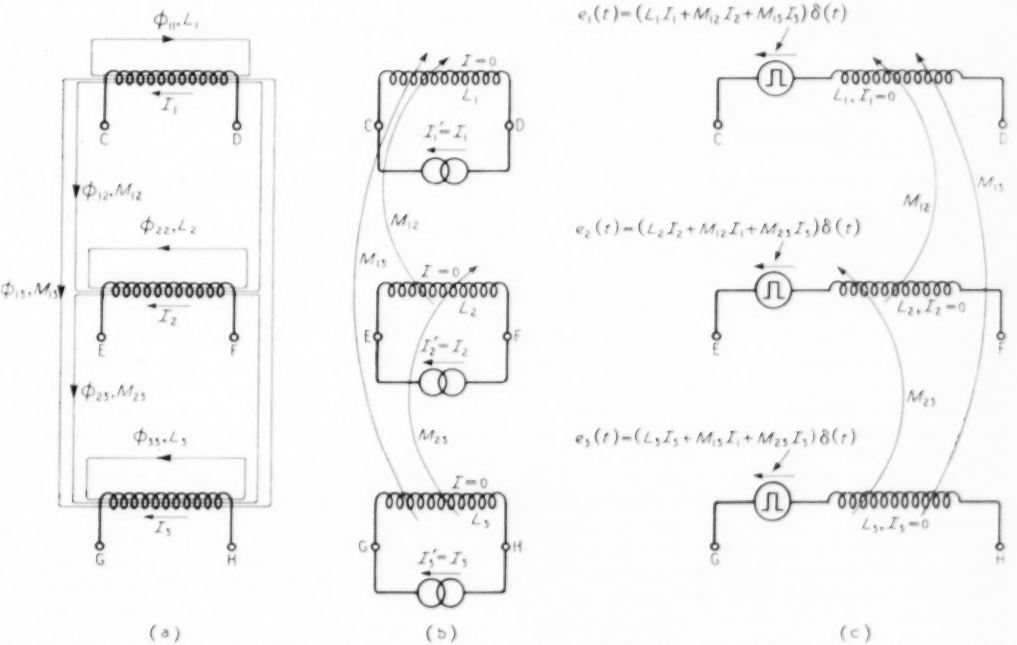

Fig. 2. *Equivalent circuits of magnetized coils, where I_1, I_2, I_3 are the initial currents, I_1', I_2', I_3' are the currents in the equivalent current generators, and $e_1(t)$, $e_2(t)$, $e_3(t)$ are voltage pulses in the equivalent voltage generators.*

of Figs. 1 and 2 as given functions of time and, starting with the differential equations and using the Laplace-transform method, express the voltages between these terminals in terms of the algebraic symbols selected for the currents and initial conditions, once for the actual network and once for the equivalent networks.

4. Examples

In the examples the Laplace-transform method is used; consequently, a generator generating a unidirectional quantity U appears as a generator generating the quantity U/p, and a pulse generator generating a pulse $P.\delta(t)$ at zero time, appears as a generator, generating the e.m.f. P. In the equivalent circuit diagrams the symbols for alternating voltage and current generators are used to denote unidirectional as well as impulsive sources of energy.

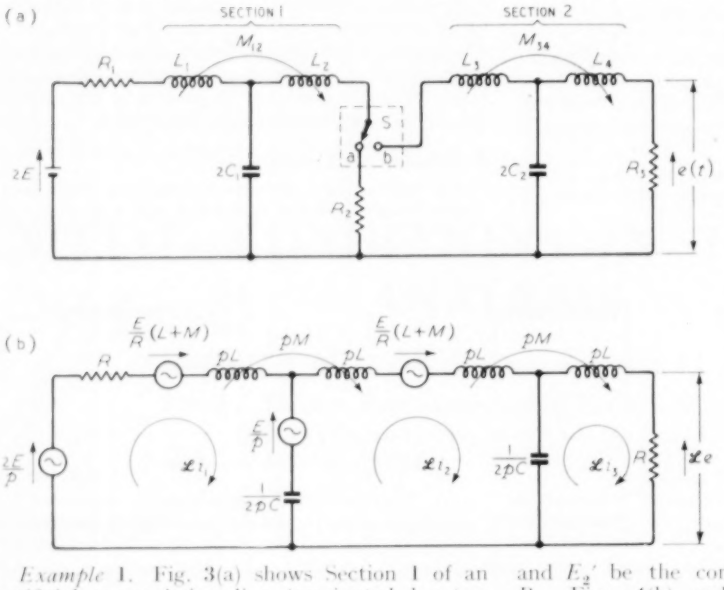

Fig. 3. *Sudden insertion of a section of an artificial transmission line (a) and its equivalent circuit (b).*

Example 1. Fig. 3(a) shows Section 1 of an artificial transmission line terminated by two equal resistances $R_1 = R_2 = R$ and energized by a unidirectional voltage $2E$. The inductances $L_1 = L_2 = L$ have series-aiding[6] mutual inductance M_{12}. A possible way of comparing the behaviour of lines of this type for different parameter values is to compute the voltages $e(t)$ appearing at the termination $R_3 = R$ of the further identical Section 2 ($L_3 = L_4 = L$; $M_{34} = M_{12} = M$; $C_2 = C_1 = C$), after an infinite-speed make-before-break two-way switch S has been switched over from position 'a' to position 'b'. Fig. 3(b) shows the circuit resulting from the theorems, if the initial conditions are replaced by additional voltage generators. If the Laplace transforms $\mathcal{L}i_1(t)$, $\mathcal{L}i_2(t)$, $\mathcal{L}i_3(t)$ of the circulating mesh-currents $i_1(t)$, $i_2(t)$, $i_3(t)$ are considered as unknowns, we obtain the following equations by applying Kirchhoff's Second Rule:

$$[R + pL + 1/(2pC)]\,\mathcal{L}i_1(t) + [-1/(2pC) + pM]\,\mathcal{L}i_2(t) = E[1/p + (L+M)/R] \quad (1)$$

$$[-1/(2pC) + pM]\,\mathcal{L}i_1(t) + [+1/(pC) + 2pL]\,\mathcal{L}i_2(t) + [-1/(2pC) + pM]\,\mathcal{L}i_3(t) = E[1/p + (L+M)/R] \quad (2)$$

$$[-1/(2pC) + pM]\,\mathcal{L}i_2(t) + [R + pL + 1/(2pC)]\,\mathcal{L}i_3(t) = 0 \quad (3)$$

We compute $\mathcal{L}i_3(t)$, $\mathcal{L}e = R\,\mathcal{L}i_3(t)$ and then the time function $e(t)$.

Example 2. A certain time-base circuit can be approximately represented by the circuit of Fig. 4(a). The values are given of the network parameters L_1, L_2, M, C, R_1 and R_2, and the voltage E. The switch S is alternately open for the given time interval t_1 and closed for the given time interval t_2. After recurrency has been established, let the currents in the coils be $I_1 = 0$ and I_2 at the end of t_1, and I_1' and I_2' at the end of t_2. Let E_2 and E_2' be the corresponding voltages across R_2. Figs. 4(b) and 4(c) show the equivalent circuits at the beginning of t_2 and t_1. $\mathcal{L}i_1'(t)$, $\mathcal{L}i_2'(t)$, $\mathcal{L}i_1(t)$, and $\mathcal{L}i_2(t)$ are the currents in the primary and secondary coils of the circuits of Fig. 4(b) and (c) respectively. The application of Ohm's generalized law and Kirchhoff's First Rule to the circuit of Fig. 4(b) results in

$$(R_1 + pL_1)\,\mathcal{L}i_1'(t) + pM\,\mathcal{L}i_2'(t) = E/p \quad (4)$$

$$pM\,\mathcal{L}i_1'(t) + pL_2\,\mathcal{L}i_2'(t) = e'_2 \quad (5)$$

$$\mathcal{L}i_2'(t) + I_2/p = CE_2 + (pC + 1/R_2)\,\mathcal{L}e_2'(t) = 0 \quad (6)$$

After finding the time functions $i_1'(t)$, $i_2'(t)$ and $e_2'(t)$ we compute I_1', I_2', and E_2' from

$$I_1' = i_1'(t_2) \quad \ldots \quad \ldots \quad \ldots \quad \ldots \quad (7)$$

$$I_2' = i_2'(t_2) + I_2 \quad \ldots \quad \ldots \quad \ldots \quad (8)$$

$$E_2' = e_2'(t) \quad \ldots \quad \ldots \quad \ldots \quad \ldots \quad (9)$$

I_1', I_2', and E_2' are linear functions of E, E_1, and I_2.

The network equations of the circuit of Fig. 4(c) are

$$\mathfrak{L}i_1(t) + I_1'/p = 0 \quad \ldots \quad \ldots \quad \ldots \quad \ldots \quad (10)$$

$$\mathfrak{L}e_2(t) = pM\,\mathfrak{L}i_1(t) + pL_2\,\mathfrak{L}i_2(t) \quad \ldots \quad (11)$$

$$\mathfrak{L}i_2(t) + I_2'/p = CE_2' + (pC + 1/K_2)\mathfrak{L}e_2 = 0 \quad \ldots \quad \ldots \quad \ldots \quad (12)$$

From these equations $i_2(t)$ and $e_2(t)$ can be computed in which t is counted from the beginning of t_1. The values $i_2(t_1)$ and $e_2(t_1)$ result as linear functions of E, E_1, and I_1. The conditions

$$I_2 = i_2(t_1) + I_2' \quad \ldots \quad \ldots \quad \ldots \quad (13)$$

$$E_2 = e_2(t_1) \quad \ldots \quad \ldots \quad \ldots \quad \ldots \quad (14)$$

enable us to find the value of E_2 and I_2, so that the functional relation between the voltage across R_2 and time can be investigated in detail.

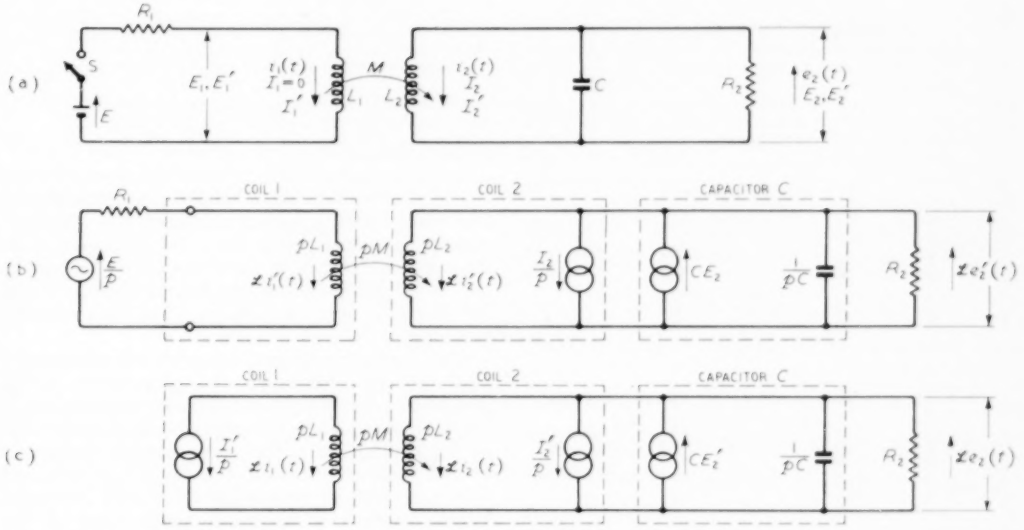

Fig. 4. *Time-base circuit (a), and two equivalent circuits (b) and (c) after closing and opening switch S respectively.*

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[1] Jaeger, J. C., "An Introduction to the Laplace Transformation," Methuen, London, 1949.

[2] Ward, E. E., "Impedance and the Laplace Transform", *Wireless Engineer*, June 1951, Vol. 28, p. 192.

[3] Carter, G. W., "The Simple Calculation of Electrical Transients", Cambridge University Press, 1944, pp. 54-66.

[4] Lee, A., and MacDonald, D. K. C., "The Extended Employment of Thevenin's Theorem", *Wireless Engineer*, November 1945, Vol. 22, p. 535, Fig. 5, etc.

[5] See Reference 1, p. 71.

[6] Hebb, M. H., Horton, C. W., and Jones, E. B., "On the Design of Networks for Constant Time Delay", *J. appl. Phys.*, June 1949, Vol. 20, p. 616, Fig. 3.

ABSTRACTS AND REFERENCES INDEX

The Index to the Abstracts and References published throughout 1952 is in course of preparation and will, it is hoped, be available towards the end of this month. As supplies are limited our Publishers ask us to stress the need for early application for copies. Included with the Index is a selected list of journals scanned for abstracting, with publishers' addresses. Price 3s. 9d. (including postage).

HIGH-FREQUENCY BRIDGE WITH VARIABLE-RATIO ARMS

By J. E. Houldin, Ph.D., B.Eng., A.M.I.E.E. and G. T. Thompson, B.Sc.(Eng.), A.C.G.I., A.M.I.E.E.

(Communication from the Staff of the Research Laboratories of The General Electric Co., Ltd., Wembley, England.)

SUMMARY.—The circuit described is intended for high-frequency measurements on aerials, cables and similar impedances. An experimental model has been made for the frequency range 10–100 Mc/s. The circuit uses variable-ratio arms, in the form of a circular arc of transmission line with a movable feed point.

The range of parallel resistance of the unknown impedance may be from one quarter to four times the value of the standard resistor, which itself may have any value between 50 and 250 ohms. The reactance range of the bridge varies: in the experimental bridge it is equivalent to ± 45 pF when the ratio arms are equal.

LIST OF SYMBOLS

f = frequency (cycles per second)
Z_0 = characteristic impedance of ratio arms (ohms)
β = phase constant of ratio arms = $2\pi/\lambda$ (cm^{-1})
λ = wavelength in ratio arms = c/f (cm)
c = wave velocity in ratio arms (cm per second)
C_r = capacitance per cm length of ratio arms = $1/(cZ_0)$ (farads)
L_r = inductance per cm length of ratio arms = Z_0/c (henrys)
l = total length of ratio arms (cm)
l_2 = length of ratio arm connected to left-hand impedance (R_x, C_x and C_2' in parallel) (cm)
R_x = parallel resistive component of unknown impedance (ohms)
C_x = parallel capacitive component of unknown impedance (farads)
C_2' = capacitance of left-hand variable capacitor, K_2, including all stray capacitance except that of ratio arms (farads)
l_1 = length of ratio arms connected to right-hand impedance (R and C_1' in parallel) (cm)
R = resistance of standard resistor (ohms)
C_1' = capacitance of right-hand variable capacitor, K_1, including all stray capacitance except that of ratio arms (farads)
m = ratio of R_x to R
n = ratio of lengths of arms = l_2/l_1
n' = $\sin \beta l_2 / \sin \beta l_1$
L_s = equivalent series inductances of variable capacitors (henrys)
C_1 = calibration capacitance of capacitor K_1 (farads)
C_2 = calibration capacitance of capacitor K_2 (farads)
K = correction capacitance (farads)

1. Introduction

THIS bridge has been developed for the measurement of unbalanced impedances of the order of 100 ohms at frequencies between 10 and 100 Mc/s. The unknown impedance is measured in terms of a standard resistor, two variable capacitors and the ratio of two lengths of transmission line. The instrument is relatively simple to use and, unlike most radio-frequency bridges, does not require an external radio-frequency amplifier and detector.

Auxiliary equipment required is limited to a signal generator giving 2 V r.m.s. output with low harmonic content and a sensitive d.c. galvanometer. A slotted line may be used for such measurements with the same auxiliary equipment, but when designed for frequencies below about 100 Mc/s it becomes bulky and not readily portable.

The accuracy obtained depends on the frequency and on the value of the impedance being measured. At the low end of the frequency range the accuracy is high, the errors being mainly those of calibration; in the experimental bridge at 100 Mc/s an accuracy of about ± 3% is obtained with impedances mainly resistive and having a value between a half and twice that of the standard. In general, larger errors can be expected outside this range.

The use of variable resistors at radio frequency is eliminated by using variable ratio arms and a fixed standard resistor, which may have any value between 50 and 250 ohms.

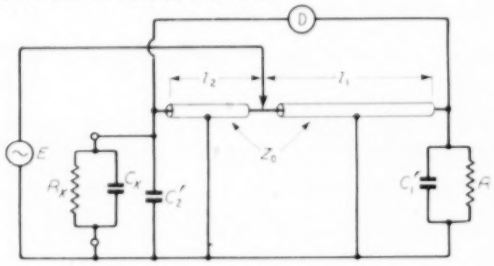

Fig. 1. *Transmission-line circuit of bridge.*

2. Theory

It will be assumed that the variable ratio arms can be represented by two lengths of lossless transmission line of equal and constant characteristic impedance, Z_0. The schematic circuit of the bridge is shown in Fig. 1.

For any uniform transmission line of length l,

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characteristic impedance Z_0 and propagation constant P, terminated in an impedance Z, the voltage, V_T, at the termination is given by

$$V_T = V_S \frac{Z}{Z \cosh Pl + Z_0 \sinh Pl}$$

where V_S is the voltage applied to the input of the transmission line.

Since the transmission line is assumed to be lossless the propagation constant becomes $j\beta$ and thus

$$V_T = \frac{V_S}{\cos \beta l + j \frac{Z_0}{Z} \sin \beta l}$$

When the bridge is balanced, the voltages across the left- and right-hand impedances must be equal in magnitude and phase.

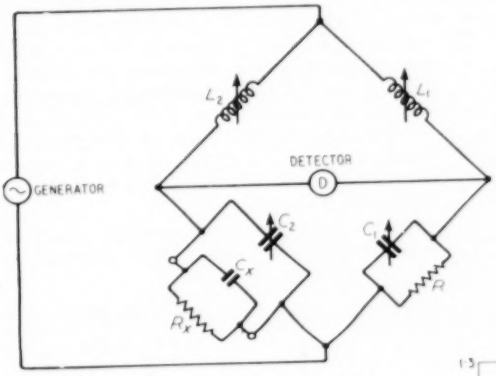
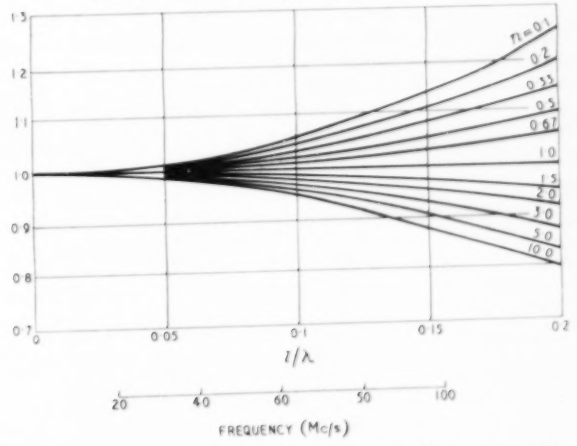


Fig. 2 (above). *Low-frequency equivalent circuit of bridge.*

Fig. 3 (right). *High-frequency ratio correction factor.*



In the bridge

$$Z_1 = \frac{1}{1/R + j\omega C_1'}$$

and

$$Z_2 = \frac{1}{1/R_x + j\omega C_x + j\omega C_2'}$$

Therefore,

$$\frac{E}{\cos \beta l_1 + jZ_0 (1/R + j\omega C_1') \sin \beta l_1} \frac{E}{\cos \beta l_2 + jZ_0 (1/R_x + j\omega C_x + j\omega C_2') \sin \beta l_2} \quad \ldots \quad (1)$$

By separating the real and imaginary parts of this equation, expressions for the unknown resistance and capacitance are obtained:

$$R_x = \frac{\sin \beta l_2}{\sin \beta l_1} R \quad \ldots \quad (2)$$

$$C_x = \frac{\cos \beta l_2 - \cos \beta l_1}{\omega Z_0 \sin \beta l_2} + C_1' \frac{\sin \beta l_1}{\sin \beta l_2} - C_2' \quad (3)$$

By putting $Z_0 = \beta/\omega C_r$ in equation (3) these equations reduce at low frequencies to

$$R_x = nR \quad \ldots \quad (4)$$

$$\text{and } C_x = \frac{C_r l}{2}\left(\frac{1-n}{n}\right) + \frac{C_1'}{n} - C_2' \quad \ldots \quad (5)$$

$$\text{or } C_x = \frac{C_1' + \frac{C_r l}{2}}{n} - \left(C_2' + \frac{C_r l}{2}\right) \quad \ldots \quad (6)$$

where $n = l_2/l_1$

It will be seen that if the calibration of the variable capacitors is made to include half the distributed capacitance of the ratio arms ($C_r l/2$), the unknown capacitance at low frequency is given by

$$C_x = C_1/n - C_2 \quad \ldots \quad (7)$$

$$\text{where} \quad C_1 = C_1' + \frac{C_r l}{2}$$

$$\text{and} \quad C_2 = C_2' + \frac{C_r l}{2}$$

The above low-frequency balance conditions of the transmission line circuit of Fig. 1 are the same as those obtained for the simple bridge of Fig. 2, where the ratio L_2/L_1 is denoted by n.

The unknown resistance may be calculated from equation (4) and for many applications this is sufficiently accurate. When it is desired to allow for the finite length of the ratio arms, equation (2) is used; this may conveniently be done by using the correction factor given in the graph of Fig. 3. This is plotted against l/λ and corresponding

frequencies for the experimental bridge. It will be seen from this graph that for $l/\lambda < 0{\cdot}1$ the theoretical error produced by using the low-frequency formula of equation (4) is less than 5% for values of n between about 0·15 and 7. For the experimental bridge at 100 Mc/s, the theoretical error is less than 6% for values of n between about 0·5 and 2.

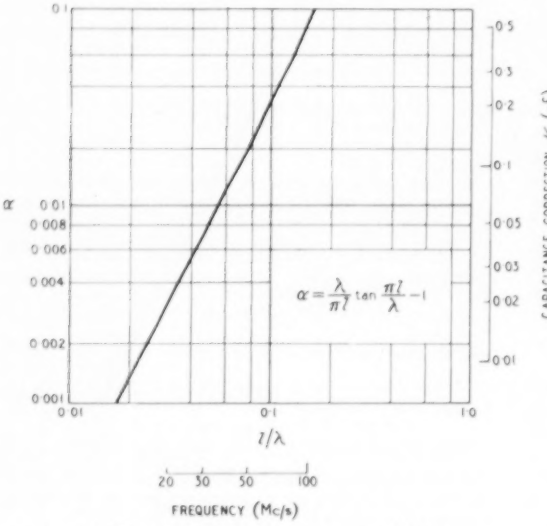


Fig. 4. *High-frequency capacitance correction.*

Measurements on an experimental bridge were made to confirm this theoretical ratio-arm error; resistors of 50 and 100 ohms were used and the ratio-scale readings were noted for different frequencies. The error thus found experimentally was always less than that expected from the theory, as shown in Table 1.

TABLE 1

Frequency (Mc/s)	n'/n	Observed change of ratio from low-frequency value
20	1·000	—
100	1·056	1·03
150	1·132	1·08
200	1·255	1·19

Many experiments were made to investigate this discrepancy, but without success. Brief details of these tests are given in the Appendix.

For high values of unknown resistance at large values of n a correction due to the diode load resistors being in parallel at radio frequency with the standard and unknown resistances becomes appreciable. The resistors in the experimental bridge are 10 kΩ, and with a standard resistor of 100 ohms an uncorrected measurement of a resistance of 400 ohms will be in error by about 4% from this cause. It should be noted that the radio-frequency resistance of the diode loads will be very nearly equal to the d.c. resistance at 10 Mc/s, but will have dropped to about 8 kΩ at 100 Mc/s.

The correction of the indicated unknown capacitance is less straightforward. First, the capacitance readings are corrected in the usual way for the effect of residual series inductance of the tuning capacitors. The effective capacitance is

$$C_1' = \frac{C_1 - C_r l/2}{1 - \omega^2 L_c (C_1 - C_r l/2)} + \frac{C_r l}{2} \qquad (8)$$

and similarly for C_2, where L_c is the equivalent series inductance of each of the variable capacitors. In the experimental bridge the maximum value of $C_1 - C_r l/2$ is 55 pF and L_c is $0{\cdot}55 \times 10^{-8}$H. Thus at 100 Mc/s the correction to $C_1 - C_r l/2$ amounts to about 14% at maximum reading. At 70 Mc/s it is about 6%.

The unknown capacitance is given by equation (3) and, putting $Z_0 = \beta/\omega C_r$, this may be written

$$C_x = \frac{C_r}{\beta}\left[\frac{\cos \beta l_2 - \cos \beta l_1}{\sin \beta l_2}\right] + \left[C_1' \frac{\sin \beta l_1}{\sin \beta l_2} - C_2'\right] \qquad (9)$$

Now, assume that the unknown capacitance may also be given correctly by the low-frequency formula of equation (6) when n' is substituted for n and an equal correction capacitance, K, is added to both the calibration capacitances, thus

$$C_x = \frac{C_1' + \frac{C_r l}{2} + K}{\frac{\sin \beta l_2}{\sin \beta l_1}} - \left(C_2' + \frac{C_r l}{2} + K\right) \qquad (10)$$

If the assumption is to be valid, the values of C_x given by equations (9) and (10) must be equal. Then

$$\frac{C_r}{\beta}\left[\frac{\cos \beta l_2 - \cos \beta l_1}{\sin \beta l_1}\right] = \left(\frac{C_r l}{2} + K\right)\left[\frac{\sin \beta l_1}{\sin \beta l_2} - 1\right];$$

$$\text{or } \frac{C_r l}{2} + K = \frac{C_r}{\beta} \tan \frac{\beta l}{2};$$

$$\text{or } K = \pm \frac{C_r l}{2} \qquad (11)$$

where $z = \frac{\lambda}{\pi l} \tan \frac{\pi l}{\lambda} - 1 \approx \frac{\pi^2}{3} \left(\frac{l}{\lambda} \right)^2$ .. (12)

The factor z is plotted against l/λ in Fig. 4. The theoretical capacitance correction, K, for the experimental bridge is also shown in Fig. 4, assuming that the wave velocity in the ratio arms is the same as that in free space, the capacitance $C_d/2$ being 6·2 pF. The correction, K, is + 0·5 pF at 100 Mc/s.

The bridge is not intended as a precision instrument and, in most applications, the various corrections investigated above are not made. For example, if it is desired to adjust the matching of a system of characteristic impedance Z_0 ohms, where Z_0 is of the order of 100 ohms, measurements will automatically become more precise as the desired condition is approached, particularly when the standard resistance is chosen to be equal to the characteristic impedance of the system.

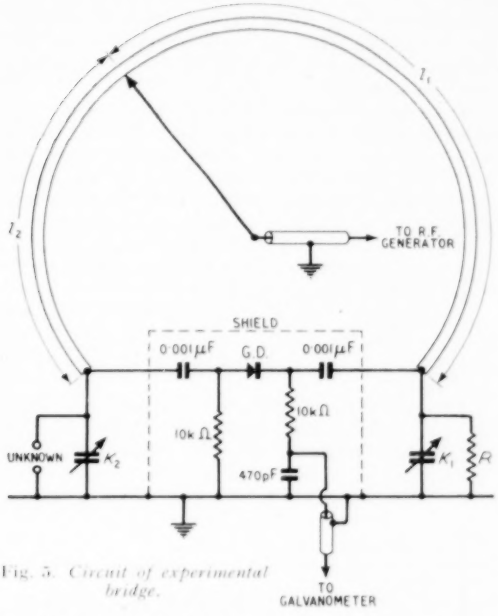


Fig. 5. *Circuit of experimental bridge.*

3. Experimental Bridge

The full circuit of the experimental bridge is shown in Fig. 5, which gives approximately the relative disposition of the components.

The ratio arms, L_1 and L_2, are formed of a rectangular section brass conductor in the shape of a circular arc of about 310° and about 46 cm long. The estimated Z_0 of these ratio arms, when mounted between parallel plates as seen in Fig. 6, is about 125 ohms. The ends of this bar are soldered to the fixed vanes of the two variable capacitors, K_1 and K_2 (Wingrove and Rogers, Type C28-41, with one frame distance piece removed). The high-potential terminals for the connection of the unknown impedance and the standard resistor are, as nearly as is mechanically

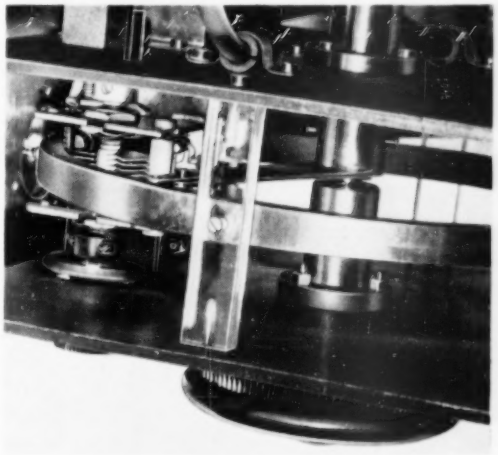


Fig. 6. *Internal view of experimental bridge.*

possible, at this junction. The coupling capacitors for the germanium-crystal rectifier (G.D. in Fig. 5) are also connected to these points (G.E.C. Type GEX35 is a suitable rectifier). By thus defining the measuring point as closely as possible, it was hoped to keep the residual series terminal inductance to a low value. This was measured and found to be about $0{\cdot}35 \times 10^{-8}$ H.

The high-frequency input to the bridge is conducted to the insulated wiper arm through coaxial cable and a brush, bearing on a slip ring at the centre of rotation of the arm.

The unknown impedance is connected between the earthed top plate of the instrument and the left-hand measuring point, at which there is a 0 B.A. tapped hole into which various connectors may be screwed. For example, when the impedance to be measured terminates in a coaxial-cable connector socket, the outer of a modified plug is fixed to the top panel and the inner connector is soldered to a short length of 0 B.A. studding which is screwed into the measuring point. Fig. 7 shows the bridge set up for use in this way, the connector on the bridge being a G.E.C. Type 3 plug. The outer of the modified Type 3 plug has a disc of $1\frac{1}{4}$ in. diameter soldered to it, and this disc is held against the top plate of the bridge by a knurled ring which screws into a threaded collar fixed to the top of the bridge.

The germanium-crystal rectifier, its load

resistors and filter capacitor are in a small screening box mounted on the internal dividing plate at the side remote from the ratio arms and the variable capacitors. The detector is connected to the measuring point and the corresponding junction point on the standard side through two small cylindrical 1,000-pF ceramic capacitors. When the bridge is not balanced, a rectified current passes through the galvanometer. The magnitude of this current depends on the out of balance radio-frequency voltage and the sum of the variational resistance of the crystal diode and the resistance of the loads. For small currents the variational resistance of the diode used is about 20 kΩ. The value of the load resistors must be a compromise. Too high a value reduces the sensitivity of the bridge; too low a value involves errors in the measured value of the unknown resistance, since the left-hand diode load resistor

Fig. 7. *Bridge set up for measurement of impedance terminating in G.E.C. Type 3 socket.*

is in parallel at radio frequency with the unknown and the right-hand one is in parallel with the standard resistor. It will be noted that at a ratio-arm setting of unity this error, like many others in the circuit, becomes zero. The load resistors chosen were 10 kΩ. With this value a galvanometer of about 1 microampere f.s.d. is adequately sensitive down to a frequency of 25 Mc/s when the input radio-frequency voltage to the bridge is 2 V; at lower frequencies down to 10 Mc/s a galvanometer of about 10 times this sensitivity is required. This relatively large increase in sensitivity is necessary because the output of the germanium detector is proportional to the square of the radio-frequency voltage across it.

The balance condition is approached by adjustment of the ratio control and of one or both of the variable capacitors. It is preferable to arrive at a balance where one of the capacitors is at a minimum, since this minimizes errors due to series inductance in the capacitors and is also the condition for greatest sensitivity.

Some tests were made using an amplitude-modulated source and a tuned audio amplifier as detector and satisfactory results were obtained. The simplicity of a galvanometer was a large factor in choosing this type of presentation, but the other method might prove superior for field use and could be made as sensitive, although a high-gain narrow-band audio amplifier would be required. When this method was first tried a number of balance points was obtained. This was traced to the presence of modulation-frequency voltage in the output of the signal generator used. At a modulation frequency of 3 kc/s, a carrier frequency of 20 Mc/s, and a radio-frequency output of 1 V, the unwanted modulation-frequency voltage was 35 microvolts. This value of modulation-frequency voltage, when applied to the bridge, is sufficient to account for the spurious balances observed.

In order to obtain a clear balance on the galvanometer, it was found necessary to use a low-pass filter, between the generator and the bridge, to reduce the magnitude of harmonics in the generator output. Without the filter, it was possible to obtain only a minimum reading, but this was found to differ by a very small amount, and in no case more than 1% on the ratio scale, from the true balance point.

The approach to the balance point is rapid except when the impedances become mainly reactive; e.g., 250 ohms and 40 pF in parallel at 100 Mc/s.

The standard resistors used are of the high-stability carbon-film type, the dimensions of which are shown in Fig. 8. The cylindrical resistance film is deposited on a ceramic rod, the connections being made by brass end caps. In the

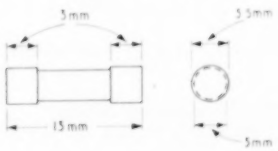


Fig. 8. *Dimensions of standard resistors. (Welwyn Electrical Laboratories high-stability carbon resistors, Types 3UA 3611 and 3PA 3611, ½-watt.)*

experimental bridge one end of the standard resistor is held in a cup which screws into a 0 B.A. hole in an identical position at the end of the right-hand ratio arm to that in the unknown or left-hand side. The other end is held in a small cup soldered to the centre of a beryllium-copper diaphragm. The periphery of this diaphragm is soldered to a brass ring, which may be fixed to the

top plate panel of the bridge (Figs. 7 and 9). Standard resistors of 50, 100 and 200 ohms retain their d.c. value of resistance up to 100 Mc/s to within 1%. The series inductance of a dummy brass resistance and diaphragm assembly was found to be about $0{\cdot}73 \times 10^{-8}$ H, the dummy resistor itself being about $0{\cdot}29 \times 10^{-8}$ H. The inductance of low values of these resistors with diaphragm assembly was also deduced from impedance measurements made at frequencies up to 450 Mc/s and was found to agree well ($0{\cdot}75 \times 10^{-8}$ H) with the value measured for the dummy brass resistor.

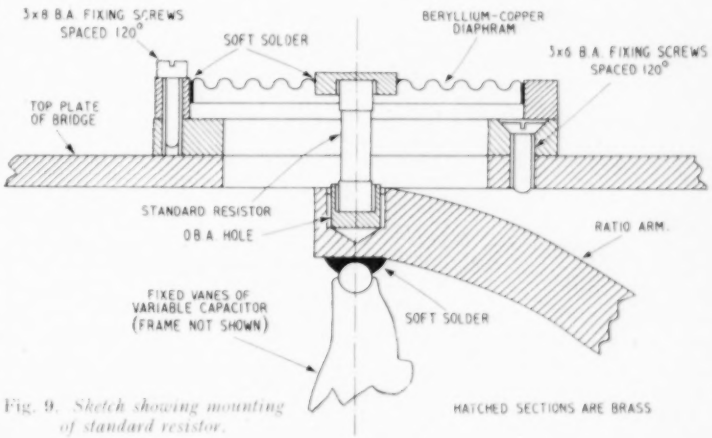


Fig. 9. *Sketch showing mounting of standard resistor.*

4. Method of Calibration

The ratio-arm scale is first calibrated at low frequency (10 Mc/s) using resistors similar to the standard and having values between 10 and 1,000 ohms. A diaphragm arrangement, similar to that used on the standard side, is used to connect one of two resistors on the unknown (left-hand) side, the other resistor being in the normal standard position. A temporary degree scale and cursor are fixed to the ratio-arm spindle, and the angles shown on this scale for various balances with different combinations of resistors are noted. Let the resistance ratio (K_X/K), corrected if necessary for the resistances of the diode loads, be m. When $1/(1 + m)$ is plotted against the angular movement of the wiper arm, θ_2 in Fig. 10, a straight line results. For the experimental bridge this was true over the range $0{\cdot}1 < m < 10$. This linear relationship is to be expected, since, at low frequency

$$K_X = R\, l_2/l_1; \text{ or } K_X = \frac{\theta_2}{\theta - \theta_2} K;$$

$$\text{or } m = \frac{\theta_2}{\theta - \theta_2}; \text{ or } \frac{1}{1+m} = 1 - \frac{\theta_2}{\theta}$$

From this graph a table of angles for the desired ratio scale marks is prepared and the cylindrical scale engraved, using a degree dividing head. The ratio scale of the experimental bridge is calibrated from 0·1 to 10. The reduced accuracy at high frequencies and the restriction of the range of reactance measurable make the extremes of this scale of little use, and a range of 1/4 to 4 is now considered sufficient.

The capacitors are calibrated in two steps. After disconnecting the low-potential ends of the diode load resistors and lifting the wiper arm, the change of capacitance of each capacitor at low frequency (1 Mc/s) is measured, the capacitance-measuring device being connected to the ratio arm and the case of the bridge. Then the total capacitance of the ratio arms and capacitor minima is measured. Since the bridge is symmetrical, this capacitance may be divided equally between the two capacitors and added to the incremental calibrations. (The equality of the minima of the two capacitors was checked before the bridge was assembled.) This is the low-frequency capacitance calibration (C_1 and C_2) and is engraved on the capacitance dials.

The total capacitance of the ratio arms is determined before the capacitors are fitted: this value ($C_r l$) is required if it is desired to prepare a capacitance-correction curve similar to Fig. 4.

Subsidiary coloured scales were provided on the experimental bridge on the ratio and C_2 dials, to make the bridge direct reading in capacitance over part of its range. The steps involved are: (1) a balance is obtained in the usual way, (2) the appropriate one of the pair of subsidiary scales on the ratio dial gives a new value to which the scale capacitance C_1 of capacitor K_1 is adjusted, and (3) the bridge is rebalanced using capacitor K_2. The unknown capacitance is then given directly on a subsidiary scale (of the same colour as that of the subsidiary scale used on the ratio dial) on the capacitor K_2. The values of C_1, given by the subsidiary scale on the ratio dial, produce a constant value of C_1/n for the second balance, and since $C_x = (C_1/n) - C_2$ it is possible to engrave a direct-reading capacitance scale (C_x) on the dial of capacitor K_2. The scales are correct only at low frequency, and, since also the calculation of C_x from the instrument readings is in any case not difficult, it is now considered that the provision of

these subsidiary scales does not warrant the extra labour involved in calibration.

5. Further Development

Experience with the experimental bridge has suggested certain modifications which would improve the performance either generally or over a particular frequency range.

The upper limit of the useful frequency range is determined by the length of the ratio arms, the high-frequency behaviour of the standard resistors, and the magnitude of the residual impedances; the most important of these residuals is the inductance of the variable capacitors. If large corrections are not to be applied, these considerations restrict the upper frequency to about 100 Mc/s. The ratio-arm error can be reduced by using a shorter arc, but this will reduce the sensitivity at the low-frequency end of the range. However, it would enable the upper-frequency limit to be extended to about 200 Mc/s, provided that variable capacitors of lower inductance than those in the experimental bridge could be used. The standard resistor would preferably be above 80 ohms, since for this value the series inductance of about $0{\cdot}75 \times 10^{-8}$ H produces about 1% error at 200 Mc/s.

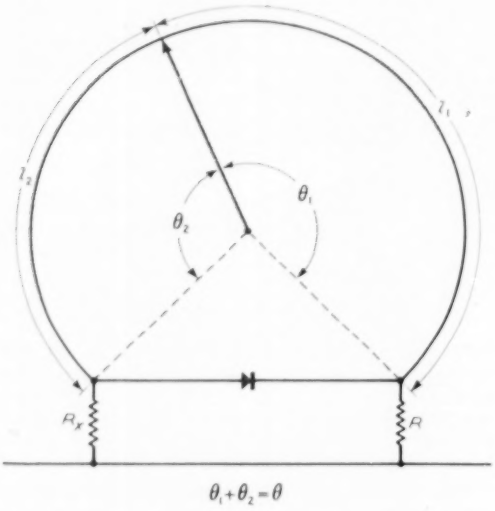


Fig. 10. *Diagram showing angles and lengths referred to in Section* 4.

An increase in the characteristic impedance of the ratio arms would reduce their distributed capacitance; this would have the advantage of reducing the minimum calibration capacitances of the variable capacitors (these minima are 16 pF in the experimental bridge), the magnitude of the high-frequency correction of Fig. 4, and increasing the sensitivity at low frequencies.

An increase in the size of the earthed plates, on both sides of the line, relative to the transmission line would improve its uniformity. This would be desirable, although tests have not revealed any error directly attributable to this cause in the experimental bridge.

The measuring point lies about $\frac{1}{8}$ in. below the top surface of the bridge and centrally disposed in a 1-in. diameter hole in this surface. Various measurements of residual parameters have shown a considerable spread. It is thought that this may be due to the terminal arrangement and, therefore, that a coaxial type of terminal (such as that suggested by W. H. Ward[2] and adopted in some radio-frequency bridges), although introducing more residual impedance, might enable the residual impedance to be determined more precisely.

The connections of the ends of the ratio arms to the fixed vanes of the capacitors could be made by short removable pieces of copper foil. This would enable the ratio-arm capacitance and the capacitances of the variable capacitors to be determined separately.

APPENDIX

The following tests were made to elucidate the discrepancy between the theoretical frequency errors of the bridge and the experimental results. (1) The two sections of the transmission line forming the ratio arms were screened from one another and from the radial wiper arm. (2) A temporary germanium diode detector was mounted externally to the bridge, to investigate spurious couplings to the detector. (It can be shown that capacitance coupling from the radio-frequency input to both sides of the detector reduces the ratio-arm error; in fact, it is possible to compensate a large portion of the error by this means). (3) Screens were fitted to eliminate as far as possible capacitance coupling from the ratio-arms and wiper to the fixed vanes of the variable capacitors. (4) The resistors were screened at their lower ends, by thin copper discs with $\frac{1}{4}$-in. diameter holes, from the ends of the ratio-arms. (5) Measurements were made with one 100-ohm resistor on one side of the bridge and two 100-ohm resistors in parallel on the other, to eliminate the effect of possible differences in the radio-frequency behaviour of 50- and 100-ohm resistors. (6) The non-uniformity of the transmission line, which is a circular arc supported by three "Perspex" pillars between square plates and in a square box (see Fig. 6), was accentuated by placing a copper-foil strip, connected to the body of the bridge, near to one ratio-arm, and also by making measurements with the bridge out of the containing box. (7) The detector connections were moved 4 mm on either side of their normal position opposite the measuring points.

In all these experiments it was found that for a given frequency the measured changes of ratio from the low-frequency value did not spread more than $\pm$ 0·8% from a mean, up to a frequency of 100 Mc/s.

REFERENCES

[1] Brit. Pat. Applns. 28979/50 and 28 80/50.
[2] *Proc. Instn elect. Engrs*, July 1949, Vol. 96, Part III, No. 42, p. 305.

DISTRIBUTED AMPLIFIERS

Mutual-Inductance-Coupled Type

By B. Murphy, M.Eng., Grad.I.E.E.

SUMMARY.—This paper outlines a design procedure for 'distributed amplifiers' of the mutual-inductance-coupled type.

The problems of output voltage and output matching are considered in more detail than hitherto. For amplifying short, random, unidirectional signals, a simple method of increasing the gain and output voltage, while maintaining the time-delay constant, by over-running the valves has been developed. The construction of two amplifiers and the results obtained with them are described.

1. Introduction

THE design and construction of amplifiers of the 'distributed' type was undertaken as a preliminary to the investigation of d.c. corona light pulses, which probably have time durations from 4×10^{-8} sec to 10^{-5} sec.[1,2]

In a distributed amplifier stage, the grids of the valves are connected to a lumped low-pass transmission line, the stray capacitances of the valves being the shunt capacitances of the line (Fig. 1). The anodes are connected to a similar line with the same velocity of propagation as the grid line. The input signal v_0 propagates along the grid line causing current $v_0 g_m$ (where g_m is the mutual conductance of a valve) to flow through each valve. This current divides in the anode line, $\frac{1}{2}v_0 g_m$ going backwards and $\frac{1}{2}v_0 g_m$ going forward. The backward-flowing currents cancel if the line is correctly terminated. The forward-flowing currents add to give $\frac{1}{2}v_0 g_m n$ (n is the number of valves in the stage) at the output, if there is no reflection. The mutual conductances of the valves effectively add while the stray capacitances are separated; individual valves in the stage can therefore be operated at less-than-unity gain and a stage gain of greater than unity be obtained. Stages may be cascaded to give high gains at far greater bandwidths than are obtainable with conventional amplifier circuits.

A considerable amount of work has recently been carried out on distributed amplifiers.[3,4,5,6,7] These can be classed according to the type of transmission line used. Undoubtedly the simplest type of amplifier uses shunt-derived constant-k lines, but has poor amplitude and phase characteristics. The paired-anode connection[3] enables the amplitude-frequency characteristic to be made flat but the maximum attainable gain and output voltage for any given valve are halved and thus this type of connection is unsuitable for an output stage.

The mutual-inductance circuit uses centre-tapped coils (Fig. 2). The lines take the configuration of low-pass m-derived ladder networks with m greater than one.[3,4,5,6] The phase characteristic is linear for a large percentage of the cut-off frequency and if $m = 1{\cdot}27$ the amplitude characteristic for a lossless line is flat for about 80% of the cut-off frequency.[8] This type of circuit has a higher gain-bandwidth product than the constant-k type for any given valve.

The bridged-T circuit gives a good amplitude-frequency characteristic and the lines can be simply terminated by a resistor without the use of a terminating half-section, but the circuit is more complex.[3]

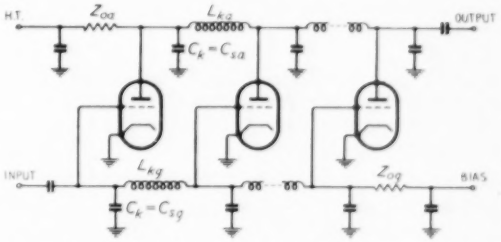


Fig. 1. *Basic circuit of distributed amplifier.*

2. Design

A linear phase characteristic is most important for pulse amplification and the mutual-inductance-coupled circuit is most suitable.[9]

For a low-pass m-derived filter:—

$$Z_0 = \sqrt{\frac{L_k}{C_k}} \qquad \ldots \quad \ldots \quad \ldots \quad (1)$$

$$f_c = \frac{1}{\pi\sqrt{L_k C_k}} \qquad \ldots \quad \ldots \quad \ldots \quad (2)$$

where Z_0 is the characteristic impedance of the line

f_c is the cut-off frequency of the line

L_k, C_k are the constants of the prototype low-pass line.

If C_s is the stray capacitance of a particular electrode (grid or anode), then the minimum value of C_k for the m-derived line connecting those electrodes is C_s/m. In the design of an amplifier the choice of a suitable valve fixes C_s, an optimum value for m is 1·27 and the choice of f_0 fixes Z_0

MS accepted by the Editor, May 1952.

and L_k. The theoretical performance may then be obtained from the following equations[3,6]:—

$$G = \tfrac{1}{2}Z_{0a}g_m \frac{nm^3}{\left[m^2 - (1 - m^2)x_k^2\right]\sqrt{m^2 - x_k^2}} \quad (3)$$

$$\phi = 2n \tan^{-1}\left\{\frac{mx_k}{\sqrt{m^2 - x_k^2}}\right\} \quad .. \quad .. \quad (4)$$

$$T = \pi f_c \frac{nm^3}{\left[m^2 - (1 - m^2)x_k^2\right]\sqrt{m^2 - x_k^2}} \quad (5)$$

$$z = z_0 \frac{x_k^2 m^3}{\left[m^2 - (1 - m^2)x_k^2\right]\sqrt{m^2 - x_k^2}} \quad (6)$$

$$\frac{A}{A_0} = e^{-nz/2}\frac{\sinh nz/2}{\sinh z/2} \quad .. \quad .. \quad .. \quad (7)$$

where G equals the gain of a stage utilizing n valves,
Z_{0a} equals the characteristic impedance of the anode line,
x_k equals f/f_c where f is the frequency, f_c the cut-off frequency,
ϕ is the phase shift,
T is the time-delay,
z is attenuation per valve due to the cathode-lead inductance,
z_0 is $g_m L_{cath}\omega_c$,
L_{cath} is the inductance of the cathode lead,
A is the amplitude in the case with losses,
A_0 is the amplitude in the loss-free case.

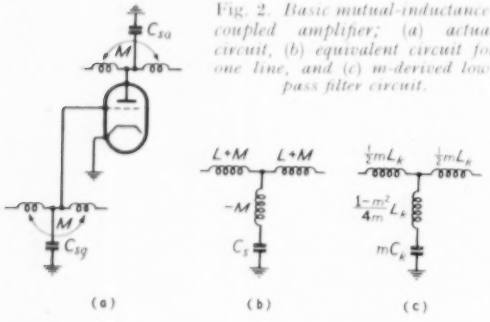


Fig. 2. *Basic mutual-inductance-coupled amplifier; (a) actual circuit, (b) equivalent circuit for one line, and (c) m-derived low-pass filter circuit.*

If an unavoidable electrode and lead inductance L_s is present, the electrical line constants for a required m-will be given by:—

$$L = \frac{m^2 + 1}{4m}L_k - L_s \quad .. \quad .. \quad (8)$$

$$M = \frac{m^2 - 1}{4m}L_k + L_s \quad .. \quad .. \quad (9)$$

$$C = \frac{C_s}{m} \quad .. \quad .. \quad .. \quad .. \quad (10)$$

The lines should be terminated[10] with m-derived half sections with $m = 0{\cdot}6$.

The detailed design of the lines may be carried out in the following manner:—

For short continuous close-wound single-layer solenoids[11] with the ratio $\frac{\text{mean diameter}}{\text{length}}\frac{d}{l}$ between 0 and 20 the current sheet inductance L_1 is given with an accuracy of $\pm 2\%$ by

$$L_1 = \frac{a^2N^2}{(9 - al/5)\,a + 10l} \text{ microhenries for } a \text{ and } l \text{ in inches} \quad .. \quad .. \quad .. \quad .. \quad (11)$$

where N is the number of turns in the coil and a is the mean radius of the coil.

In this case for a continuously-wound coil, where $d = 2a$ is the mean diameter (Fig. 2).

$$2L + 2M = \frac{d^2N^2}{\left(18 - \frac{1}{5}\frac{d}{l}\right)d + 40l} \quad .. \quad (12)$$

$$L = \frac{d^2(N/2)^2}{\left\{18 - \left(\frac{2}{5}\right)\frac{d}{l}\right\}d + 20l} \quad .. \quad (13)$$

$$\text{hence } \frac{L + M}{L} = \frac{2\left\{\left(18 - \frac{2}{5}\frac{d}{l}\right)\frac{d}{l} + 20\right\}}{\left(18 - \frac{1}{5}\frac{d}{l}\right)\frac{d}{l} + 40} \quad (14)$$

where M is the mutual inductance between the coil halves of inductance L.

The curve of $\frac{L + M}{M}$ versus $\frac{d}{l}$ as calculated from equation (14) is shown in Fig. 3 with curve of $\frac{L + M}{M}$ published by Kelley shown dotted. The deviation is probably due to the use here of the more accurate equation (11) for L_1.

Equation (14) can be expressed as a quadratic in $\frac{d}{l}$ which has real roots for $\frac{L + M}{L}$ less than 1·62 (i.e., $\frac{L}{M}$ greater than approximately 1·62) corresponding to a value of $\frac{d}{l} = 7{\cdot}25$. Since equation (11) is accurate within $\pm 2\%$ for values of $\frac{d}{l}$ up to 20 it will hold for half of a coil of $\frac{d}{l} = 10$. Therefore, the maximum attainable ratio of $\frac{L + M}{L}$ is 1·62.

If one is working with values of $\frac{d}{l}$ less than 3, as is more usual, then ignoring the $(d/l)^2$ term in equation (14) and rearranging we have

$$\frac{d}{l} = \frac{2{\cdot}2}{\frac{L}{M} - 1} \qquad \ldots \quad \ldots \quad \ldots \quad (15)$$

The winding pitch p is the axial distance between the centres of consecutive turns and can be related to d, L and l. Rearranging equation (13) we have, since $p = l/N$

$$\frac{d^3}{p^2} = L\left[18\frac{d}{l} - \frac{2}{5}\left(\frac{d}{l}\right)^2 + 20\right]\frac{d}{l} = B \quad \ldots \quad (16)$$

or

$$\log d = 2/3 \log p + \log B^{\frac{1}{3}} \quad \ldots \quad \ldots \quad (17)$$

A plot of $\left[18\frac{d}{l} - \frac{2}{5}\left(\frac{d}{l}\right)^2 + 20\right]\frac{d}{l}$ against $\frac{d}{l}$ as shown in Fig. 4 and for any value of L and $\frac{d}{l}$ the term B, and hence $B^{\frac{1}{3}}$, may easily be found. Equation (17) may then be expressed graphically, on log-log characteristics, as a straight line, as illustrated in Fig. 5. From this linear graph, appropriate values of d and p can be chosen for any given electrical design.

Pollack[12] states that for frequencies between 4 and 25 Mc/s an optimum value of p is $D/0{\cdot}7$ where D is the wire diameter. For actual construction the most simple value of p is probably $2D$.

In order to reduce coupling between separate coils to negligible values the coils should be

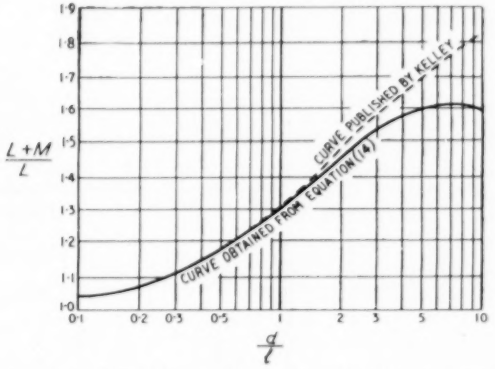


Fig. 3. *Relation between $(L + M)/L$ and d/l for a single-layer coil.*

spaced so that the distance between adjacent end turns of successive separate coils is at least equal to the coil diameter.

A suitable design procedure for mutual-inductance coils may be summarized for one line as follows:

1. Choose the required f_c.
2. Choose suitable valves thus fixing g_m, C_s, L_s.
3. Choose m.
4. Calculate L_k from $L_k = \frac{1}{\pi^2 f_c^2 C_s}\left(\frac{m}{2}\right)^2$ [i.e., equations (2) and (10)].
5. Calculate Z_0 from the expression

$$Z_0 = \frac{m}{\pi f_c C_s} \quad \ldots \quad \ldots \quad \ldots \quad \ldots \quad (18)$$

obtained by eliminating $L_k C_k$ from equations (1), (2), and (10).

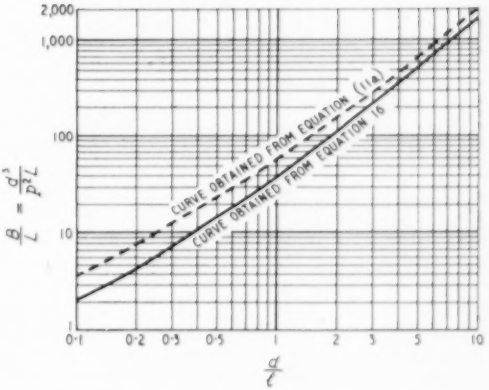


Fig. 4. *Relationships simplifying the mechanical design of coils and terminations.*

6. Calculate L, M from equations (8) and (9).
7. Find the appropriate value of d/l from Fig. 3.
8. Find the appropriate value of B using Fig. 4.
9. Choose d, and find p from Fig. 5.
10. Knowing d calculate the length l.
11. Knowing l and p calculate the number of turns.
12. Re-substitute the quantities in equation (11) to check. Choose N to the nearest half turn.

For coils of round wire with spaced turns the low-frequency inductance L_0 is given by

$$L_0 = L - 0{\cdot}0319aN(A + B) \quad \ldots \quad (19)$$

where

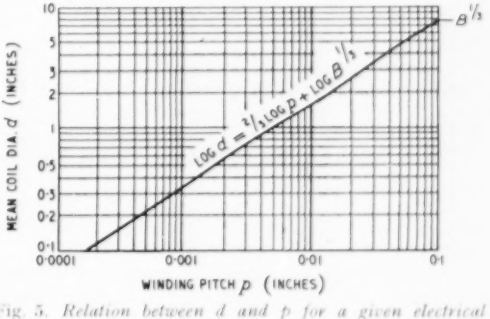


Fig. 5. *Relation between d and p for a given electrical design of coil.*

$$A = 2{\cdot}3 \log_{10} 1{\cdot}73 \frac{D}{p} \quad \ldots \quad \ldots \quad \ldots \quad (20)$$

and

$$B = 0{\cdot}336\left(1 - \frac{2{\cdot}5}{N} + \frac{3{\cdot}8}{N^2}\right) \quad \ldots \quad (21)$$

$$\frac{d^3}{p^2 L} = \left[\left(18 - \frac{1d}{5l}\right)\frac{d}{l} + 40\right]\left(\frac{d}{l}\right) \quad \ldots \quad (11a)$$

The left-hand side of this expression is known for each coil of a termination and the value of d/l and therefore l may be found directly from the

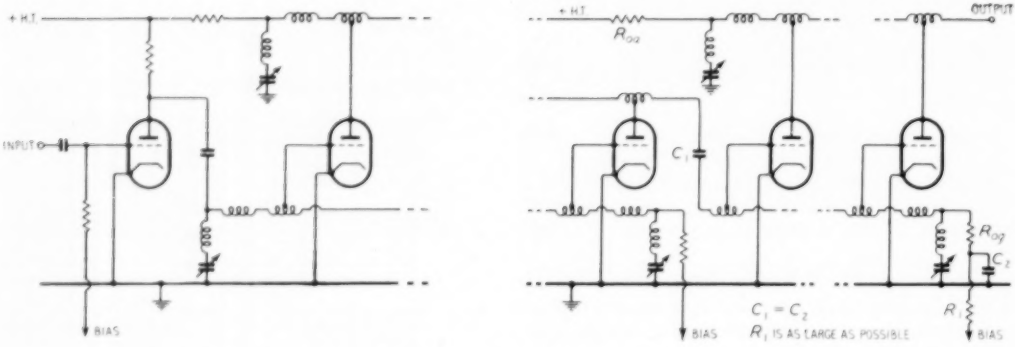


Fig. 6. (a) Use of buffer amplifier for low-frequency compensation and (b) circuit giving good low-frequency response without a buffer amplifier.

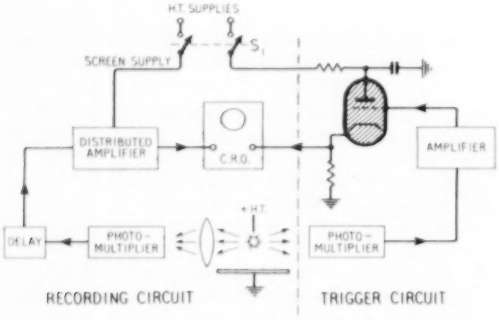


Fig. 7. Diagram of apparatus for measuring light pulses produced by d.c. corona.

A is accurate to within 1% for all values of D/p, and B is accurate to within 1% for N not less than five turns. B is about 5% high for $N = 4$ and 20% high for $N = 3$.

A correction to the current sheet inductance may be obtained using equations (19), (20) and (21). If the correction is large the design can be suitably adjusted but in the range of coils used for distributed amplifiers the correction appears to be negligible.

A more accurate design of coils can be obtained[13] but the above procedure is simple and sufficiently accurate for normal ranges of coil.

The mechanical design of the terminations may be settled completely using equation (11) which can be rewritten as

dashed curve of Fig. 4. It is necessary to check the correction as given by equations (19), (20) and (21).

The effect of the stray lead inductance is to fix a minimum physically-realizable value of L_k for a given m. This is clearly seen as follows:—
Rearrange equations (8) and (9)

$$L_k = \frac{\left(1 \cdot \frac{L}{M} + 1\right)}{(m^2 + 1) - \frac{L}{M}(m^2 - 1)} L_s \quad \ldots \quad (22)$$

but L/M cannot be greater than 1·62 if the above procedure is adopted; therefore for a given value of m and L_s the minimum physically-realizable value of L_k will be given by putting $\frac{L}{M} = 1{\cdot}62$ in the above expression.

Further, from equations (2) and (22)

$$f_c = \frac{1}{\pi\sqrt{C_s L_s}} \sqrt{\frac{\left(\frac{L}{M} + 1\right) - m^2\left(\frac{L}{M} - 1\right)}{4\left(\frac{L}{M} + 1\right)}} \quad (23)$$

If $\frac{L}{M} = 1{\cdot}62$, equation (23) expresses the maximum physically-realizable cut-off frequency obtainable from any given valve. Thus, for a valve with $C_s = 10$ pF and $L_s = 0{\cdot}02\,\mu$H for a given electrode, the line connecting those electrodes will not be physically realizable for a cut-off

frequency greater than approximately 300 Mc/s for $m = 1$ and approximately 280 Mc/s for $m = 1{\cdot}27$.

Equation (23) illustrates the importance of low lead and electrode inductances in valves for this particular application.

The greatest deviation at high frequencies from the theoretical loss less amplitude characteristic is caused by attenuation due to grid loading[6] which can be estimated from equations (6) and (7). The effect of grid loading may be compensated for in the paired-anode type of amplifier by leaving some anodes unpaired. In any type of distributed amplifier some compensation may be achieved over a limited frequency range by connecting a small inductance in series with the screen-grid lead.

When stages are cascaded, the greatest deviation at low frequencies is due to the coupling capacitors. The use of buffer amplifiers [Fig. 6(a)] whose load at high frequencies is the characteristic impedance of the grid line, enables a large measure of compensation to be attained at low frequencies. The circuit shown in Fig. 6(b) enables a flat amplitude characteristic to be obtained down to frequencies as low as 200 c/s for $C_1 = 0{\cdot}01\ \mu$F and $R_{0g} = 200$ ohms.[7]

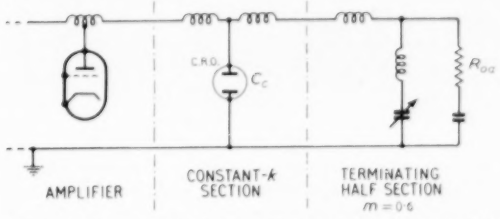


Fig. 8. *Arrangement for terminating an amplifier when it is used with a c.r. tube.*

3. Output Voltage

Distributed amplifiers have a most important application in conjunction with high-speed cathode-ray oscilloscopes for the recording of high-speed transients[5, 7] and, in this application, output voltages of the order of 80-100 V are desirable so that, for the wider bandwidth amplifiers, push-pull output becomes essential. It is possible to increase the output voltage and gain of an amplifier considerably by over-running the valves. This technique becomes practicable when signals are to be amplified whose duration is short compared to the period between amplifying successive signals, particularly if the signals are unidirectional. Fig. 7 shows a particular application of this technique. It was desired to examine the light pulses occurring in d.c. corona. These pulses are of short duration and occur randomly so that it is necessary to trigger the c.r.o. by the same pulse which it is desired to record. The switch S_1, which is normally open so that the amplifier valves are not conducting, is closed to record, and applies the supply voltage to the anode of the triggering thyratron and the screen-grids of the distributed amplifier. The first pulse which occurs after closing the switch S_1 causes the thyratron to conduct and trigger the c.r.o., while the output pulse from the recording photomultiplier is delayed before being amplified and presented on the cathode-ray tube. The triggering thyratron remains conducting until switch S_1 is opened again, so that a single recording is obtained each time the switch S_1 is closed. In this application it is satisfactory to operate the switch manually, though no doubt an effective switch could be made to operate also by a random pulse.

With a mutual-inductance-coupled single-ended amplifier consisting of 8 EF91 valves with $f_c = 212$ Mc/s, $Z_{0a} = 394$ ohms, an output voltage of 80 to 100 V is obtained with $V_a = 350$ V, $V_{g_2} =$

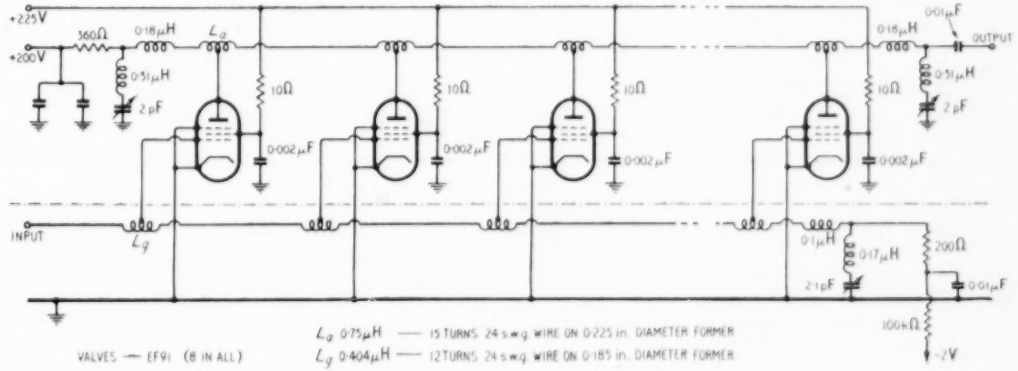


Fig. 9. *Circuit of experimental distributed amplifier.*

350 V and $V_{g1} = 0$ for negative signal pulses and $V_{g1} = -3$ V for positive signal pulses.

4. Output Matching

The output impedance into which distributed amplifiers usually work is the stray capacitance and lead inductance of a cathode-ray tube. If this stray capacitance is approximately of the same magnitude as the shunt capacitance of the anode lines, the oscilloscope may be matched into the amplifier anode line as the shunt capacitance of a constant-k half-section. The anode line may then be left unterminated at the output with a resultant increase in gain and output voltage. If the line is unterminated the amplitude characteristic cannot be flat[3,7] due to reflections. However, the peaks of the amplitude characteristic crowd to the edges of the pass band as the number of valves n in a stage increases.[3] Therefore, to obtain a reasonably-flat amplitude response over a given pass band, one can design the amplifier with a wider bandwidth than necessary, which decreases Z_{0t} and thus the gain and output voltage, and leave the line unterminated at the output, which gives a theoretical increase in gain and output voltage of 2 over the correctly-terminated case. Alternatively, one can design the amplifier to the bandwidth desired, which will give a larger Z_{0t} than in the first case, and terminate the amplifier correctly at the output, which will theoretically reduce the gain and output voltage to a half of the values with the anode line unterminated.

When the output of the anode line is unterminated, the termination of the other end becomes more critical but this method is probably the best for bandwidths up to 100 Mc/s.

When the stray capacitance (C_c) of the deflection circuit of the c.r.o. is equal to or less than the shunt capacitance ($C_{s\,s} = C_s/m$) of the anode line prototype section, the matching at the output of the amplifier may be done satisfactorily by connecting a constant-k T section, whose shunt capacitance is C_c together with any necessary shunt trimming capacitance, in series with the output of the amplifier. A terminating half section with $m = 0{\cdot}6$ and a terminating resistor are connected to the open end of the T section to complete the matching (Fig. 8). If C_c is greater than C_s/m then C_s may be increased by means of trimmer capacitors until $C_s = C_c$, but this reduces the value of Z_0 and hence the gain and output voltage for a given value of f_c by a factor of $C_s/(mC_c)$.

Alternatively, the value of C_c may be effectively decreased by connecting it in series with an adjustable capacitor (C'). The output voltage from the amplifier is then applied to the c.r. oscilloscope through a capacitance potential divider which decreases the overall gain by a factor of $C_s/(mC_c)$. This is the better method since it involves no change to the actual amplifier when the amplifier load circuit is changed. The

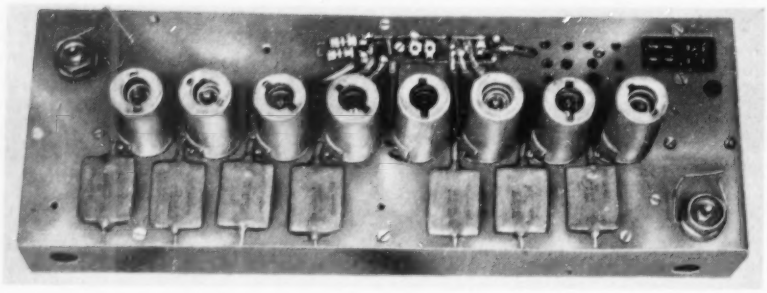


Fig. 10 (above). *Top view of amplifier of Fig. 9.*

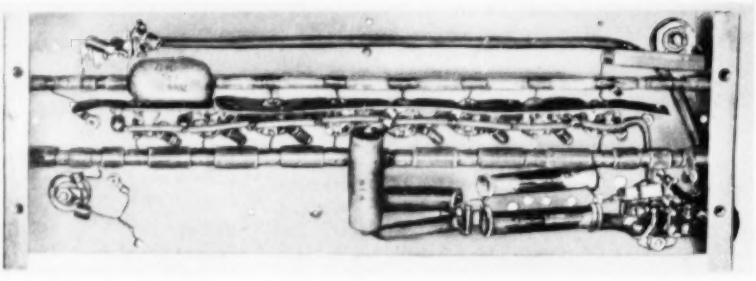


Fig. 11 (right). *Under view of amplifier of Fig. 9, showing the delay lines.*

serious reduction in gain and output voltage is evident, since for typical values of $C_{sk} = 5$ pF, $m = 1{\cdot}27$ and $C_c = 7$ pF the gain and output are approximately halved if an ideal match at the output is sought.

The use of secondary-emission valves, such as the EFP 60 or high-frequency transmitting tetrodes such as the QQVO6-40, should enable suitable output voltages to be obtained with large bandwidths.

5. Construction

Two amplifiers have been constructed with a useful bandwidth of 100 Mc/s, without the necessity of selecting valves.

The first amplifier (Figs. 9, 10 and 11) uses 8 EF91 valves and was designed to have a cut-off frequency $f_c = 212$ Mc/s, $Z_{0k} = 394$ ohms, and $Z_{0g} = 212$ ohms. The lines use close-wound small-diameter coils, and are of the mutual-inductance type. They were designed to have $m = 1{\cdot}27$ but the effect of lead inductance was ignored.

Before the design of the second amplifier the values of the lead inductances of an EF91 were measured and found to be of the following order: cathode-lead inductance 0·015 μH, anode inductance plus 2 cm of wire 0·027 μH, grid inductance plus 2 cm of wire 0·025 μH.

The second amplifier (Figs. 12, 13 and 14) is a push-pull output stage using 8 EF91 valves per side in conjunction with a distributed amplifier phase inverter using two EF91 valves. The design specification is the same as for the first amplifier but the line coils were designed using the above values of the electrode and lead inductances, and are of larger diameter with spaced turns.

In each amplifier the Distrene coil formers are machined to size. In the first amplifier the coils are completely covered with a cement made by dissolving Distrene in chloroform and, since the coils are close-wound, they are wound in two halves and the ends joined at the valve pin to form an effective centre-tap. In the second amplifier the formers are grooved and the coils wound with a winding pitch p of twice the wire diameter D. A small drop of cement at the end of each coil holds them in position. The centre-tap leads are soldered on to the coils. There appears to be no appreciable difference in the performance of the amplifiers due to the different types of construction used.

In the first amplifier, decoupling each screen and screening the heater leads and bringing them to the top of the chassis were found to produce no appreciable difference. The signal connections

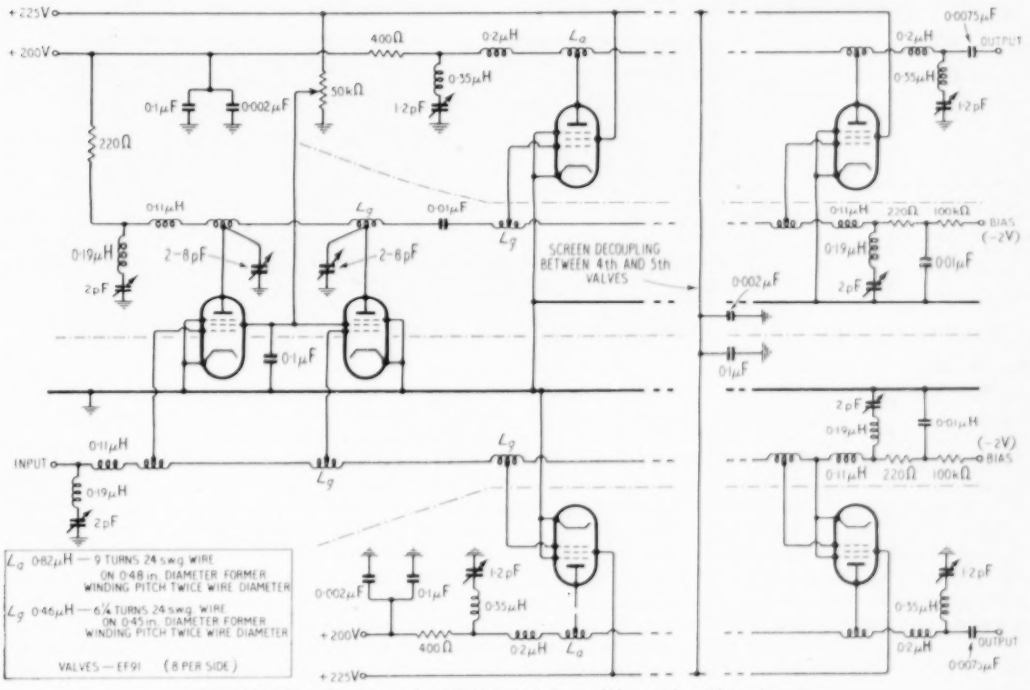


Fig. 12. *Circuit of a push-pull distributed amplifier with a phase inverter.*

were made via "Pye-plugs" but owing to their stray capacitance these have been replaced in the second amplifier by polystyrene bushes and wire leads.

In both amplifiers the grid and anode lines are screened from each other to prevent oscillation at low frequencies (10-100 kc/s), the supply leads, except the heaters, are decoupled by 0·1-μF paper capacitors shunted by 2000-pF mica capacitors, and all earth leads are of thin copper strip where possible.

A steady-state test was carried out on each amplifier in the range 5 kc/s-100 Mc/s and enabled the terminations to be adjusted more accurately. The amplitude characteristics of both amplifiers fall steadily from 10 Mc/s and are approximately 3 db down at 100 Mc/s. It is essential that any generator used in a steady-state test should have a good waveform.

Figs. 15(c) and (d) show the outputs of the amplifiers, operating in cascade when amplifying pulses identical to that of Figs. 15(a) and 15(b) after the pulses have been attenuated 62 db. The gain of the amplifiers when matched into each other is 59·5 db. When they are directly connected without intermatching the gain is 64 db. Since the input pulses are negative, the sides of the output stage are biased asymmetrically at -2 and -1 volt. With the anode-supply voltage at $+200$ V and the screen-supply voltage at 225 V the maximum output voltage at normal ratings is 100 V with the output of the amplifier not matched into the c.r.o.

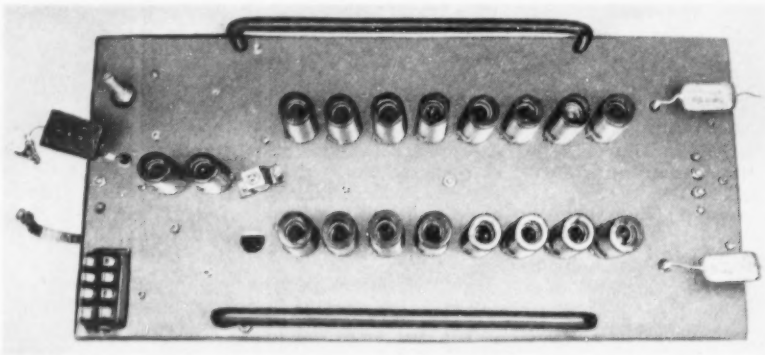


Fig. 13 (above). *Top view of amplifier of Fig. 12.*

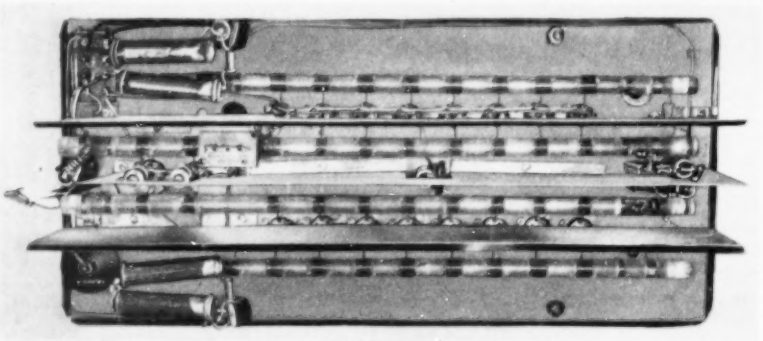


Fig. 14 (right). *Under view of amplifier of Fig. 12.*

6. Results

The terminations of the amplifiers were adjusted with the aid of a pulse-producing circuit, attenuator and high-speed single sweep c.r.o.[14] The pulse-producing circuit consisted of a delay circuit and a thyratron 2D21 discharging a length of coaxial cable through a suitable resistance termination. Fig. 15(a) is an oscillogram of a $\frac{1}{2}$-μsec test pulse before attenuation and Fig. 15(b) shows the front edge of the pulse as seen with a 0·6-μsec time sweep. The attenuator was a heavily-screened ladder network but it was not entirely satisfactory when testing both amplifiers in cascade where the degree of attenuation required was high.

The apparent performance of the amplifier increases when the amplifiers are cascaded without intermatching as can be seen in Figs. 15(j), 15(k). Fig. 15(j) shows the response of the amplifier to random noise pulses from a photo-multiplier when the amplifiers are matched into each other, and Fig. 15(k) shows the response when the amplifiers are not matched. If it is assumed that these noise pulses rise infinitely fast, the overall rise-time of the photo-multiplier amplifiers and c.r.o. is 0·006 μsec.

The performance of the phase inverter is satisfactory as may be seen from Figs. 15(e), (f), (g) and (h) which show the output from each side of the push-pull output stage under the same conditions as Fig. 15(c) and (d).

8. Acknowledgments

The author's acknowledgments are due to Professor J. M. Meek in whose laboratories this work has been carried out and to Dr. J. D. Craggs for his continuous interest and support.

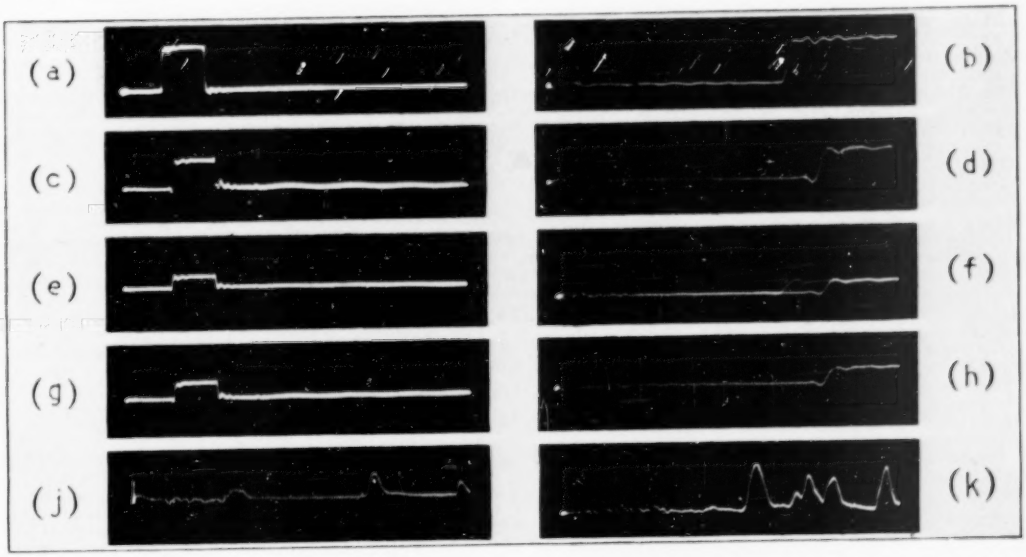


Fig. 15. *These oscillograms show, (a) $\frac{1}{2}$-μsec unattenuated test pulse; (b) its front edge; (c) and (d) the outputs of the amplifiers in cascade with input pulses (a) and (b); (e), (f), (g) and (h) the outputs of each side of the push-pull stage under the same conditions; (j) the response to random noise pulses; and (k) the response with unmatched amplifiers.*

7. Conclusions

The design procedure, construction and testing outlined above appear satisfactory for the design of mutual-inductance-coupled type of amplifiers up to approximately 200-Mc/s bandwidth.

For the highest bandwidths, the output of the amplifier must be correctly matched, involving a loss in gain and output voltage which may be difficult to overcome with the available valves. The use of secondary-emission valves should enable higher output voltages to be attained. For intermittent recording of short-duration phenomena the valves may be over-run to give approximately a three-fold increase in output voltage over that obtainable when the valves are operating at manufacturers' rating.

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CORRESPONDENCE

Letters to the Editor on technical subjects are always welcome. In publishing such communications the Editors do not necessarily endorse any technical or general statements which they may contain.

A Note on Dull-Emitter Filaments

SIR,—At a recent meeting of the Institution of Electrical Engineers only a vague reply was given to the question "what safety factor is it proper to use in respect of emission drawn compared with peak emission available on flash test?" I have looked up some old notes on this subject, in respect of thoriated tungsten filaments, and these may shed some light on the matter although the thoriated tungsten case may not be strictly comparable to that of the coated filament.

Prior to the release of information by Langmuir Patents, the research was carried out with the intention of obtaining data for the rational design and use of thoriated tungsten filaments, taking the best possible advantage of the 'excess' emission provided by the thorium over and above that provided basically by the 'bright emitter' tungsten. The ultimate aim was twofold —(a) to reduce filament-power consumption for a given performance, and (b) to increase life to the maximum economical extent.

The valve of interest at that time was one capable of standing a dissipation of 30 W at the anode, the filament current being 1 A at 6 V (when run as a bright emitter). The data given here, while applying to that particular valve, was judged to be applicable to other types in so far as the filament conditions are concerned.

The basis of the study was the 'activation' of the filament material by a process involving flashing followed by slow growth of emission at an optimum filament voltage of about two-thirds of the normal (bright emitter) voltage. The actual details of the process are not relevant to the specific point in the question posed.

The investigation covered many aspects of the treatment and operation of these dull-emitter filaments, but the particular point under consideration on this occasion is the value of the anode current which can be drawn reliably from such activated filaments. Guided by data already obtained, it was considered that for any particular condition of filament current, anode voltage and grid voltage, a balance was struck when the rate of activation (growth of emissivity) was equal to the rate of de-activation by extraction of electrons. This condition was ascertained in the following way:

The filament was flashed at 10 V for a few seconds so as to destroy all thorium emissivity. It was then run at 4 V with 200 V d.c. on the anode, the grid being held at a previously determined potential suitable for passing an anode current of 50 mA once the emission became adequate. In the space of a few minutes, the anode current had grown to 50 mA and the process was continued for another five minutes which experience had shown to be sufficient for maximum (flash) emissivity to be established. The grid was then strapped to the anode and the anode current (full emission) read; this was found to be 150 mA but, of course, soon fell to practically nothing. The process was repeated many times with minor variations of technique and the ratio of 3 : 1 confirmed.

A further check was provided by test under self-oscillatory conditions; i.e., 50 mA with anode (d.c.) potential at 1,200 V. Here again, the test was started with a de-activated filament, and zero anode current (emissivity practically nil); in the course of time, the system built up emission and oscillation started which rapidly grew to a condition where the anode current (mean) was 50 mA, after which input and output remained steady.

Prolonged field trials confirmed the stability of performance of a valve operated as described.

Perhaps an appropriately adapted technique could provide corresponding data for coated filaments.

I wish to thank the Chief Scientist, Ministry of Supply, for permission to publish this data.

N. F. S. HECHT.

London, S.W.1.
7th January 1953.

Anode Follower

SIR,—Users of the term "anode follower" are, I suggest, under an obligation to show cause why it should not be condemned as expressing an entirely false analogy. Why 'follower'? We understand and appreciate this description in 'cathode follower', where the potential of the cathode follows changes in that of the grid; but in the so-called anode follower the potential of the anode does precisely the opposite. Some of our technical terms are admittedly somewhat anomalous, but surely this is going too far! On the same principle a rejector circuit could be called a 'parallel acceptor', or a voltage antinode on a resonant line a 'voltage node' on the ground that it coincides with a current node.

M. G. SCROGGIE.

Bromley, Kent.
9th January 1953.

Noise in Interface Resistance

SIR,—A great deal of work has been done on the effects of an impedance between the coating and the core of an oxide-cathode[1, 2] since Raudorf's investigations were reported.[3] I would like to point out a hitherto unnoticed effect of such an impedance, namely, its effect on the noise-resistance of an amplifying valve.

Published results[1, 2, 3] suggest that the interface impedance is almost completely resistive at frequencies not greater than about 250 kc/s.

The generally-favoured suggestion about the cause of this impedance is that a semiconducting film is formed in the interface, giving rise to a resistance R, shunted by a capacitance. Raudorf suggests, on the other hand, that this impedance is due to the deterioration of the electrical contact between the cathode-core and the coating. In either case, some excess noise would be generated in the interface resistance (in addition to Johnson noise) when the valve is carrying current. The magnitude of the excess noise will

(a) depend on the frequency characteristics of the equipment following the valve with the interface resistance.
(b) be proportional to the square of the cathode current, I_c.

If for given frequency characteristics and cathode-current the total noise e.m.f. in the resistance R is of the same magnitude as Johnson-noise e.m.f. in a resistor R_n at room temperature, then the equivalent noise-resistance of the valve with the interface resistance can be shown to be $R_{eq} + R_n$, where R_{eq} is the noise-resistance of the valve without the interface resistance.

A supply of 'surplus' 6AC7 valves was available and the noise resistance of many of these (triode-connected) was measured, using an amplifier with pass-band extending from 20 kc/s to 200 kc/s. A large number of the valves tested showed noise-resistances between 165Ω and 190Ω, the value remaining practically independent of cathode-current for currents between 8 mA and 15 mA. Some valves were much noisier, and the noise-resistance was then strongly current dependent. For a particular

valve, a check on the effective value of g_m suggested an interface resistance of about 7Ω, while the noise resistance was 1,120Ω for $I_c = 12{\cdot}5$ mA. It was also noticed that the measured noise-resistance was linearly dependent on I_c^2.

This suggests that $R_n \gg R$. As a uniform film with this current density cannot be expected to be so noisy, this observation would back the current-constriction idea. The particles of the coating are said to have dimensions in the range 1–10μ while Eisenstein reports[4] that in a particular valve the film at the interface was found to have a thickness of 22μ after 100 hours of operation. It does not seem unlikely, therefore, that in some valves the contact area between the film and the coating gets restricted during the growth of the film in the interface.

A more rigorous experimental investigation is to be carried out soon.

Yours faithfully,

H. O. Berktay.

Department of Electrical Engineering,
The University, Birmingham.
19th December 1952.

[1] Metson, G. H., Wagner, S., Holmes, M. F. and Child, M. R.: *Proc. Instn elect. Engrs*, March 1952, Vol. 99, Part III, p. 69.
[2] Eaglesfield, C. C.: *Electrical Communication*, 1951, Vol. 28, p. 95.
[3] Raudorf, W.: *Wireless Engineer*, October 1949, Vol. 26, p. 331.
[4] Eisenstein, A.: *J. appl. Phys.*, 1949, Vol. 20, p. 776.

Cathode-Follower Operation

Sir,—In your June 1952 issue, Mr. A. J. Shimmins has treated cathode-follower circuits with capacitive loads, and three methods for improving the performance are therein analysed.

The third method, which consists in increasing the grid-to-cathode capacitance, is considered in paragraph five on page 162 and as a result it is stated that the effect of the grid-cathode capacitance is to cause an initial step in the output voltage.

This statement, I believe, requires some comment. It means, in fact, that there is a discontinuity in the voltage across the load capacitance. This could only be achieved by a current of infinite magnitude, flowing during an infinitely short interval, subject to the condition:

$$\lim_{\delta t \to 0} \int_0^{\delta t} i\,dt = \text{finite}$$

This consideration leads to the suggestion that the expression for the input current as given in formula (24) is incomplete, and that in fact a term containing Dirac's δ-function is missing. Taking R_i infinitely large I find $I_{in} = \dfrac{C_{gK}C_L}{C_{gK}+C_L} E\delta(0)$ minus the right-hand term of equation (24). If formula (24) were correct, the input current might be made zero by taking $C_{gK} = (C_{gK} + C_L)g_mR_a = A(C_{gK} + C_L)$, or $C_{gK} = C_L A/(1-A)$.

From formula (23) it then follows that the output voltage would make a step equal to AE, whereas the exponential term would disappear. This can in fact be arrived at, provided a very large input current is available; e.g., from a storing capacitor being discharged through a thyratron valve.

In most practical cases, however, the output impedance of the driving stage cannot be neglected, at best it is of the same order of magnitude as R_a. It is not difficult to show that under these circumstances very little can be gained by increasing the grid-to-cathode capacitance. Let us suppose that a step voltage of amplitude E is supplied to the input terminal of circuit (a) in Fig. 2, by a source having an output impedance $= R_a$ and let R_i be infinite. The expressions given in Appendix 3, for I_1, I_2 and e_{out} remain valid, provided E is replaced by $e_{in} = E - I_1R_a$.

We find $I_1 = (E - e_{out})\,pC_{gK}/(1 + pC_{gK}R_a)$

and $e_{in} = (E + pC_{gK}R_a e_{out})/(1 + pC_{gK}R_a)$

From this expression and the equation

$$e_{out} = e_{in}(A + pC_{gK}R_a)/\{1 + p(C_{gK} + C_L)R_a\}$$

e_{in} is eliminated and we find

$$e_{out} = AE\,\frac{1 + pT_3}{(1 + pT_1)(1 + pT_2)}$$

in which $T_3 = C_{gK}R_a/I = \dfrac{1}{I}\cdot\dfrac{C_{gK}}{C_L}\cdot R_aC_L = T_a\,m/I$

$T_1 + T_2 = \{(2 - A)C_{gK} + C_L\}R_a = \{(2 - A)m + 1\}T_a$

$T_1T_2 = C_{gK}C_LR_a^2 = mT_a^2$

putting $C_{gK}/C_L = m$ and $R_aC_L = T_a$.

The above expression may be further reduced to

$$e_{out} = AE\{K_1/(1 + pT_1) + K_2/(1 + pT_2)\}$$

in which

$$K_1 = (T_3 - T_1)/(T_2 - T_1) \text{ and } K_2 = (T_2 - T_3)/(T_2 - T_1)$$

The inverse transformation yields:

$$e_{out} = AE\{K_1[1 - \exp.(-t/T_1)] + K_2[1 - \exp.(-t/T_2)]\}$$

$$e_{out} = AE\left\{K_1\left(\frac{t}{T_1} - \tfrac{1}{2}\frac{t^2}{T_1^2} + \ldots\right) + K_2\left(\frac{t}{T_2} - \tfrac{1}{2}\frac{t^2}{T_2^2} + \ldots\right)\right\}$$

The first-order term equals:

$$AEt(K_1/T_1 + K_2/T_2) = E\,t/T_a$$

The second-order term equals:

$$\tfrac{1}{2}AEt^2(K_1/T_1^2 + K_2/T_2^2)$$

$$= \tfrac{1}{2}AE\,\frac{t^2}{T_1T_2}(T_2/T_2 + T_1/T_1 - 1)$$

$$= \tfrac{1}{2}AE\,\frac{t^2}{T_a^2}\left\{\frac{2m+1}{m} - \frac{1}{A} - \frac{m+1}{m}\right\}$$

$$= \tfrac{1}{2}E\,\frac{t^2}{T_a^2}\left\{2 - A + \frac{1-A}{m}\right\}$$

The approximation with only two terms is only useful when m is not too small.

The case $C_{gK} \to 0$ may be derived from expression (23) since in this case the impedance of the driving source may be considered negligible.

We then find:

$$e_{out} = AE\{1 - \exp.(-t/T_a)\}$$
$$= AE\{t/T_a - \tfrac{1}{2}t^2/T_a^2\}$$

Comparing the results we see that the first-order term has been improved in the ratio $1/A$, whereas the negative second-order term has increased in the ratio

$$\{2 - A + (1 - A)/m\}/A$$

For instance, for $C_{gK} = C_L$, $m = 1$ this ratio equals $3/A = 2$.

For $C_{gK} = \tfrac{1}{2}C_L$, $m = \tfrac{1}{2}$ we get $4/A = 3$,

and for $m = A/(1 - A)$, we get $1/A^2$.

The slight improvement due to the first-order term will only be felt until it is overtaken by the influence of the second-order term; i.e., between $t = 0$ and $t = 2m/(2m + 1) = T_a$.

H. H. Adelaar.

Bell Telephone Manufacturing Co.,
Antwerp, Belgium.
8th January 1953.

NEW BOOKS

Television Engineers' Servicing Manual

Edited by E. Molloy. Pp. 654 + x. George Newnes Ltd., Tower House, Southampton Street, Strand, London, W.C.2. Price 42s.

Radio Engineers' Servicing Manual

Edited by E. Molloy. Pp. 760 + viii. George Newnes Ltd., Tower House, Southampton Street, Strand, London, W.C.2. Price 42s.

Taschenbuck fur Elektrotechniker—Book 1.—Fundamentals

By Dr. Ing. Franz Moeller. Pp. 520 + viii. B. G. Teubner, Verlagsgesellschaft, Leipzig, Germany. Price D.M.19.

Telefonia a Grande Distanza, Vol. 2

By Dott. Ing. Renzo Possenti. Pp. 506 + xxiv. (In Italian.) Liberia Editrice Politecnica, Cesare Tamburini, Milan.

Electronics for Communication Engineers

By John Markus and Vin Zeluff. Pp. 610 + xi. McGraw-Hill Publishing Co., Ltd., 95 Farringdon Street, London, E.C.4. Price 85s.

This book is a collection of articles which have been published in *Electronics* during the last five years and which are here grouped under broad subject headings. They are not reprints but appear in "edited and condensed" form, although the page size and general appearance of the original are retained.

The Resonant Cavity Magnetron

By R. S. H. Boulding, O.B.E., B.Sc., M.I.E.E., A.M.I.Mech.E., F.Inst.P. Pp. 147 + vii. George Newnes, Ltd., Tower House, Southampton Street, London, W.C.2. Price 21s.

Radio Spectrum Conservation

Report of the Joint Technical Advisory Committee of the Institute of Radio Engineers and The Radio-Television Manufacturers Association. Pp. 221 + xi. McGraw-Hill Publishing Co., Ltd., 95 Farringdon Street, London, E.C.4. Price 42s. 6d.

The Amateur's Guide to Valve Selection

Pp. 48. Mullard, Ltd., Century House, Shaftesbury Avenue, London, W.C.2. Price 1s. 6d.

I.E.E. MEETINGS

10th February. "Ignition Interference with Television Reception", by A. H. Ball and W. Nethercot. Joint meeting with the Institution of Mechanical Engineers at Storey's Gate, St. James's Park, London, S.W.1, at 5.30 p.m.

11th February. "A Method of Designing Transistor Trigger Circuits", by Professor F. C. Williams, O.B.E., D.Sc., D.Phil. and G. B. Chaplin, M.Sc.

18th February. Faraday Lecture on "Light from the Dark Ages, or the Evolution of Electricity Supply", by A. R. Cooper, at Central Hall, Westminster, at 6.30 p.m.

20th February. Discussion on "Circuit Conventions, with Particular Reference to Alternating-Current Circuit Vector Diagrams", to be opened by J. G. Fleming, M.Sc.(Eng.), at 6 o'clock.

23rd February. "Radio Aids for Airport Control", by G. W. Stallibrass, O.B.E.

3rd March. "The Study of a Magnetic Inverter for Amplification of Low-Input-Power D.C. Signals", by E. H. Frost-Smith, B.A., Ph.D., and "The Parallel-T D.C. Amplifier: A Low-Drift Amplifier with Wide Frequency Response", by P. S. T. Buckerfield.

The meetings on 11th, 20th and 23rd February and 3rd March will be held at the Institution of Electrical Engineers, Savoy Place, London, W.C.2, at 5.30 p.m., with the exception of the Discussion Meeting on 20th February, which starts at 6 p.m. The other meetings are at the places and times stated above.

BRIT. I.R.E. MEETING

11th February. "Modern Trends in Communications Materials", by L. A. Thomas, B.Sc., F.Inst.P. To be held at the London School of Hygiene and Tropical Medicine, Keppel Street, Gower Street, London, W.C.1, at 6.30 p.m.

STANDARD-FREQUENCY TRANSMISSIONS

(Communication from the National Physical Laboratory)

Values for December 1952

Date 1952 December	Frequency deviation from nominal: parts in 10^{9}		Lead of MSF impulses on GBR 1000 G.M.T. time signal in milliseconds
	MSF 60 kc/s 1029-1130 G.M.T.	Droitwich 200 kc/s 1030 G.M.T.	
1	−0·5	−1	−23·7
2	−0·6	−1	−22·3
3*	−0·5	−1	−23.5
4	−0·6	−1	−19.9
5	−0·5	−1	−25.1
6	−0·5	−1	−24·9
7	−0·5	−1	−24·9
8	−0·5	0	−25·0
9	−0·4	−1	−25·5
10	−0·5	0	−24·1
11	−0·4	0	−23·7
12	−0.4	+1	−23·0
13**	—	+2	—
14*	−0·4	+2	N.M.
15**	—	+2	—
16**	—	+3	—
17**	—	+3	—
18*	−0·4	+1	−18·0
19	−0·4	+2	−17·6
20	−0·5	+2	−16·6
21	−0·4	+1	−14·9
22	−0·4	+3	−13·5
23**	—	+1	—
24**	—	+2	—
25**	—	+2	—
26**	—	+3	—
27	−0·3	+3	N.M.
28*	−0·4	+4	N.M.
29*	−0·3	+3	−4·6
30**	—	+3	—
31**	—	+4	—

The values are based on astronomical data available on 1st January 1953.

The transmitter employed for the 60-kc/s signal is sometimes required for another service.

N.M. = Not Measured.

* = No MSF Transmission at 1029 G.M.T. Results for 1429-1530 G.M.T.

** = No MSF Transmission at 1029 or 1429 G.M.T.

ABSTRACTS and REFERENCES

Compiled by the Radio Research Organization of the Department of Scientific and Industrial Research and published by arrangement with that Department.

The abstracts are classified in accordance with the Universal Decimal Classification. They are arranged within broad subject sections in the order of the U.D.C. numbers, except that notices of book reviews are placed at the ends of the sections. U.D.C. numbers marked with a dagger (†) must be regarded as provisional. The abbreviations of journal titles conform generally with the style of the World List of Scientific Periodicals. An Author and Subject Index to the abstracts is published annually; it includes a list of journals abstracted, the abbreviations of their titles and their publishers' addresses.

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ACOUSTICS AND AUDIO FREQUENCIES

534.21-14 : 534.321.9 **302**

Critical [wave-] **Length for the Propagation of Free Waves in a Viscous Fluid.**—C. Truesdell. (*C. R. Acad. Sci., Paris*, 6th Oct. 1952, Vol. 235, No. 14, pp. 702–704.) A re-examination of the theories of Stokes and others leads to the conclusion that ultrasonic vibrations of wavelength less than a critical value, dependent on the viscosity of the medium, will be overdamped and will not be propagated. Values of the critical wavelength are given for several fluids; the value for water at 15°C is 5×10^{-7} cm.

534.32 : 621.396.619.11/.13 **303**

The Limits of Perception of Amplitude- and Frequency-Modulation of a Pure Tone.—E. Zwicker. (*Akust. Beihefte*, 1952, No. 3, pp. 125–133.) Measurements were made on tones of different pitch and loudness as a function of the modulation frequency (f). Below a certain value of f, about 30 c/s for low tones, rising to 1 kc/s for tones around 10 kc/s, a.m. is perceived more readily than f.m., but above this limiting frequency no difference between a.m. and f.m. is perceptible. The effect of the slope of the response curve of a transmission system on the perceptibility of f.m. was also investigated.

534.322.1 : 621.3.018.78 **304**

The Perception of Nonlinear Distortion in the Transmission of Musical Two-Tone Combinations.—R. Feldtkeller. (*Akust. Beihefte*, 1952, No. 3, pp. 117–124.) In comparisons of the timbre of a sustained fifth before and after transmission through a nonlinear system, changes of a few parts per thousand are perceptible in the case of third-harmonic distortion, and of a few per cent with second-harmonic distortion. Loud high-pitch combinations are most susceptible to distortion. Harmonics due to the transmission system not only change the timbre but also render errors of intonation more evident.

534.615-14 **305**

Acoustic Particle-Velocity Measurements in Liquids with the Rayleigh Disk.—A. Kösters. (*Akust. Beihefte*, 1952, No. 3, pp. 171–174.) Tests by two methods confirm Wood's corrections (3945 of 1935) of the König formula for Rayleigh-disk measurements. The results are not in agreement with King's theory (638 of 1936). Rigid disks are found necessary for reliable measurements. Disk rotation is independent of the viscosity of the surrounding liquid.

534.75 **306**

The Memory for Acoustic Effects.—F. Enkel. (*Tech. Hausmitt. NordwDtsch. Rdfunks*, July/Aug. 1952, Vol. 4, Nos. 7/8, pp. 142–143.) Subjective tests show that there are two different types of musical memory, termed respectively 'linear' and 'polar'. The former discriminates on the basis of pitch differences and the latter on the basis of harmonic relations.

534.844.1 **307**

Composite Cathode Ray Oscillograph Displays of Acoustic Phenomena and their Interpretation.—T. Somerville & C. L. S. Gilford. (*B.B.C. Quart.*, Spring 1952, Vol. 7, No. 1, pp. 41–53.) A microphone receiving the test sound feeds a logarithmic amplifier; the d.c. output is applied through a directly coupled amplifier to the y-plates of a c.r.o. with a variable-speed timebase triggered at the end of a tone pulse. Reverberation time is read directly on a graticule scale aligned with the trace. Reverberation times $< 0{\cdot}1$ sec have been measured. By photographing succeeding traces as the frequency is increased, 'pulsed glide displays' are obtained. The interpretation of these is discussed and their use in studying structural vibrations is illustrated. See also *Radio Commun.* (formerly *FM-TV*), June–Aug. 1952, Vol. 12, Nos. 6–8, pp. 22–23, 43, 28, 30 & 22–23, 38.

534.845 **308**

Resonance-Type Absorbers for Water-Borne Sound.—E. Meyer & H. Oberst. (*Akust. Beihefte*, 1952, No. 3, pp. 149–170.) The materials investigated were rubber sheets 4 mm thick backed by steel plates of various thicknesses. The rubber contained cylindrical air cavities acting as resonant absorbers, the number of cavities per unit area being adapted to the thickness of the steel backing plate to obtain maximum absorption. Amplitude reflection factors of under 10%, corresponding to energy absorption of over 99%, have been obtained in the frequency range 9–18 kc/s. Measurement technique is described. Results are shown in numerous curves.

534.845 **309**

Helmholtz Resonators as Acoustic Treatment at the New Swansea Studios.—F. L. Ward. (*B.B.C. Quart.*,

Autumn 1952, Vol. 7, No. 3, pp. 174–180.) Description of the fitting of resonators for sound absorption in a large orchestral studio. The resonators consist of hollow plaster castings with flanged plaster backs, and project from the wall surface. Partitions divide each unit into eight equal cavities; cardboard tubes, of adjustable length and diameter, are inserted through holes in the front of the unit and serve to vary the cavity resonance frequency. Fabric is fitted across the mouths of the tubes to vary the neck resistance. Results of absorption measurements in the studio are to some extent inconsistent with theory. Performance tests indicate that there is little masking by the bass instruments; the adequate sound diffusion results in good tone quality and enables performers to hear each other easily.

534.845 : 534.414 **310**

Acoustic Resonators as Sound Absorbers.—A. Lauber. (*Tech. Mitt. schweiz. Telegr.-TelephVerw.*, 1st July 1952, Vol. 30, No. 7, pp. 209–213. In German and French.) Two types of resonator have been tested in the laboratory and in practice: (*a*) tubes of four different lengths, with overlapping response curves, and with characteristic impedance matched at the open end by means of cotton-wool pads; (*b*) cavity bricks with holes, constituting Helmholtz resonators. In contrast to porous absorbers, the absorption of these resonant types depends on the room damping. They are particularly applicable for frequencies below 200 c/s.

534.845.2 **311**

Building-Material Acoustics: Comparative Measurements.—G. Becker, G. Bobbert & H. Brandt. (*Akust. Beihefte*, 1952, No. 3, pp. 176–180.) A report of measurements, carried out in eight different establishments, on typical building materials and floor structures, using both airborne and impact sound. The accuracy of the various measurements is discussed in relation to the methods adopted, methods using airborne sound resulting in lower mean errors of individual measurements than those for impact sound.

621.395.623.42 : 534.6 **312**

The Suitability of Dynamic Headphones for Measurements on Frequency-Modulated Tones.—E. Zwicker & G. Gässler. (*Akust. Beihefte*, 1952, No. 3, pp. 134–139.) Resonances in the ear passage are found to be highly damped and of low intensity. By using a pair of equalizer networks with headphones, the frequency response curve of the combination can be made level to within ± 3 db from 20 c/s to 15 kc/s, so that the arrangement can be used for measurements of f.m. tones.

621.395.623.7 **313**

Metal-Cone Loudspeaker.—F. H. Brittain. (*Wireless World*, Dec. 1952, Vol. 58, No. 12, pp. 490–492.) Continuation of description noted in 18 of January. The cone, of diameter 6 in., is sufficiently rigid without being too heavy. The speech coil is of diameter 1 in. and is wound on a turned duralumin former welded to the cone. Methods of mounting in a closed box or vented cabinet or in conjunction with an acoustic labyrinth are discussed.

621.395.623.75 **314**

Horn-Loaded Loudspeakers.—D. J. Plach & P. B. Williams. (*Proc. nat. Electronics Conf., Chicago*, 1951, Vol. 7, pp. 108–114.)

621.396.645 : 621.395.625.2 **315**

A Gramophone Pickup Pre-amplifier.—E. J. Miller. (*Electronic Engng*, Nov. 1952, Vol. 24, No. 297, pp. 498–499.) Description, with detailed circuit, of an amplifier whose frequency-response curve can be adjusted to suit records with the N.A.B. characteristic or with the characteristics favoured by the E.M.I. and Decca groups of companies.

681.8 **316**

Wear of Phonograph Needles.—B. B. Bauer. (*Proc. nat. Electronics Conf., Chicago*, 1951, Vol. 7, p. 120.) Summary only.

789.983 **317**

An Electronic Music Box.—E. L. Kent & C. J. Tennes. (*Proc. nat. Electronics Conf., Chicago*, 1951, Vol. 7, pp. 115–119.) Description of an instrument using valve tone generators, with independent controls for timbre, loudness, vibrato, and slur from one note to another. Keying is effected by a perforated roll of paper.

789.983 **318**

The Clavioline.—G. H. Hillier. (*Electronic Engng*, Oct. 1952, Vol. 24, No. 296, pp. 454–455.) Description, with detailed circuit diagrams, of a small keyboard electronic instrument covering five octaves. Only individual notes can be played. Eighteen stops for adjustment of tone quality, vibrato, etc., enable various instruments to be simulated.

AERIALS AND TRANSMISSION LINES

621.392 : 621.396.67 **319**

Anti-Resonant H.F. Transmission Lines: Input Impedance Characteristics.—H. M. Barlow. (*Wireless Engr*, Dec. 1952, Vol. 29, No. 351, pp. 334–335.) Discussion on paper noted in 2430 of 1952.

621.392.21.09 **320**

The Launching of Electromagnetic Waves on a Cylindrical Conductor.—R. B. Dyott. (*Proc. Instn elect. Engrs*, Part III, Nov. 1952, Vol. 99, No. 62, pp. 408–413.) The efficiency of the launching process is found to depend on the apex angle and the aperture of the horn used, and the power loss in the process is probably due to the generation of complementary waves which dissipate their energy as heat in the conductor. Details are given of experiments on a surface-wave transmission line, using a wavelength of 6·5 cm, and suggestions are made for reducing the launching loss.

621.392.26 **321**

Electromagnetic Propagation in Two-Dielectric-Layered Parallel-Plane Waveguides.—J. van Bladel & T. J. Higgins. (*Proc. nat. Electronics Conf., Chicago*, 1951, Vol. 7, pp. 601–607.) Formulae are derived for the modes and eigenvalues of infinitely wide parallel-plane waveguides partly filled with solid dielectric, and from these formulae graphs are plotted of cut-off frequency for a range of geometrical and dielectric parameters. The characteristics of such waveguides are discussed and applications of these and corresponding rectangular waveguides are suggested.

621.392.26 : 621.315.61 **322**

Radiation from a Dielectric Wave Guide.—R. M. Whitmer. (*J. appl. Phys.*, Sept. 1952, Vol. 23, No. 9, pp. 949–953.) Continuation of the analysis noted in 17 of 1949. The modal efficiency of a dielectric slab is defined as the ratio between the power propagated in a mode (only one mode being propagated) and the sum of the guided and radiated powers; values of this efficiency are plotted for a range of parameters. In practice cylindrical rather than slab guides are used; similar values of efficiency are to be expected, viz., up to 80–90%.

621.392.26 : 621.396.677 323

Shunt Conductance of a Waveguide-Fed Slot.—H. J. Venema. (*Proc. nat. Electronics Conf., Chicago*, 1951, Vol. 7, pp. 568–581.) A method is described for calculating the shunt conductance of a rectangular slot in a perfectly conducting infinite plane, the slot being excited by means of a rectangular waveguide normal to the plane. The shunt conductance is given in terms of the aspect ratio of the slot and the excitation frequency. Experimental results confirm the theory.

621.396.67 324

A Dipole with a Tuned Parasitic Radiator.—R. King. (*Proc. Instn elect. Engrs*, Part III, Nov. 1952, Vol. 99, No. 62, pp. 406–407.) Discussion on paper abstracted in 1202 of 1952.

621.396.677.2.029.64 325

Contribution to the Study of Dielectric Aerials.—M. Bouix. (*Ann. Télécommun.*, May–Sept. 1952, Vol. 7, Nos. 5–9, pp. 217–238, 276–295, 336–348 & 350–363.) Practical arrangements of cylindrical and tapered dielectric-rod aerials are described and their radiation fields discussed. Coupling is effected by means of a circular aperture in a rectangular waveguide. Measurements of coupling impedance at wavelengths of 3 and 10 cm are reported; detailed descriptions are given of measurement apparatus and of a method for recording radiation diagrams. The theory of the dielectric radiator is then developed. A treatment of Schelkunoff's equations relative to an infinite cylinder is applied to derive a series of curves giving design parameters for EM_{11}-mode propagation. An infinite number of modes exist, for one of which there is no cut-off frequency. Numerical calculations are made for materials with a specific dielectric constant, including polythene, and design curves are given. Field equations are derived for transmission lines consisting of an outer dielectric coating on (*a*) a cylindrical conductor, (*b*) another dielectric, including the case of an air-filled tube. A theoretical treatment of the coupling and the gain of different arrays is given, with notes on practical designs.

621.396.677.3 326

Parabolic Aerials with Extremely Good Matching.—O. Laaff. (*Fernmeldetech. Z.*, Sept. 1952, Vol. 5, No. 9, pp. 406–411.) The effect of the impedance of a radiating element located in front of a parabolic reflector is analysed, and it is shown how this effect can be eliminated or, alternatively, used for matching the radiator to its feeder. The effect of axial defocusing of the radiator is discussed, and the reduction of parabola reaction on the radiator by means of a compensating disk a little distance in front of the vertex of the parabola is shown by a set of curves for a parabola 3 m in diameter and focal length 75 cm. The effect of a compensating disk on the radiation diagram is also considered.

621.396.677.5 327

The Radiation Resistance of a Small Horizontal Loop Antenna over a Conducting Plane.—R. M. Powell. (*Proc. nat. Electronics Conf., Chicago*, 1951, Vol. 7, pp. 582–597.) The radiation component of the resistance of small loop aerials is measured at u.h.f. by shielding the loop to prevent radiation, and substituting a known or calculable load resistance for the series radiation resistance of the loop. Measurements in the range 300–400 Mc/s are checked by an indirect method. The accuracy of the measurements is to within about ± 5%.

CIRCUITS AND CIRCUIT ELEMENTS

519.242 : 621.3 328

Theory of the Prediction and Filtering of Stationary Time Series according to Norbert Wiener.—H. Jacot. (*Ann. Télécommun.*, May–Aug. 1952, Vol. 7, Nos. 5–8, pp. 241–249, 297–303 & 325–335.) Digest of Wiener's book 'The Extrapolation, Interpolation and Smoothing of Stationary Time Series, with Engineering Applications' (2465 of 1950).

621.314.13 : 535.215 329

Equipment for Amplification of Weak Photoelectric Currents.—P. Dumontet. (*J. Phys. Radium*, July/Sept. 1952, Vol. 13, Nos. 7/9, Supplement, pp. 127A–128A.) Description, with detailed circuit diagram, of equipment using a double electrometer valve (Mazda Type E2) the currents in which are modulated by a square wave applied to the extraction grids, the photoelectric voltage being applied to the control grids.

621.314.25 330

Changing the Phase of a Low-Frequency Sinusoid.—P. Huggins. (*Electronic Engng*, Oct. 1952, Vol. 24, No. 296, pp. 462–464.) Description of various methods suitable for manual or automatic control, or combined automatic and manual control, of the phase of a sinusoidal low-frequency voltage.

621.314.25 : 621.392.26 331

Modified Magic-Tee Phase Shifter for Microwaves.—R. H. Reed. (*Tele-Tech*, June 1952, Vol. 11, No. 6, pp. 50–52.) The modified unit described has the symmetrical arms parallel to each other, thus allowing both short-circuiting plungers to be linked to a common drive. The E- and H- plane arms are replaced by 'odd' and 'even' coupling slots. Owing to the existence of several sources of impedance mismatch in the complete phase shifter, which uses a second magic-T junction, a special alignment procedure is necessary.

621.314.3† 332

Basic Operating Principles of Magnetic Amplifiers.—E. V. Weir. (*Proc. nat. Electronics Conf., Chicago*, 1951, Vol. 7, pp. 235–240.)

621.314.3† 333

Low-Input-Power-Level Magnetic Amplifiers.—L. W. Buechler. (*Proc. nat. Electronics Conf., Chicago*, 1951, Vol. 7, pp. 254–259.)

621.314.3† 334

Rules of Similitude for Magnetic-Amplifier Systems.—L. A. Finzi & H. L. Durand. (*Proc. nat. Electronics Conf., Chicago*, 1951, Vol. 7, pp. 498–514.) Rules are established which enable the properties of magnetic-amplifier systems to be deduced from the results of suitable tests on a 'model' amplifier or analogue computer. The method covers cases in which model and prototype have different core materials and different circuits.

621.314.3† : 621-526 335

The Application of a 60-Cycle Magnetic Amplifier to a Position-Indicating Servomechanism.—A. E. Schmid. (*Proc. nat. Electronics Conf., Chicago*, 1951, Vol. 7, pp. 515–522.)

621.314.3† 336

A Magnetic Amplifier of High Input Impedance.—G. M. Ettinger. (*Proc. nat. Electronics Conf., Chicago*, 1951, Vol. 7, pp. 523–528.)

621.314.3† 337

Use of the Flux-Charge Concept in Magnetic-Amplifier Analysis.—P. M. Kintner. (*Proc. nat. Electronics Conf., Chicago*, 1951, Vol. 7, pp. 529–536.)

621.314.3† 338

A Series Magnetic Amplifier with Inductive Loading.—T. G. Wilson. (*Elect. Engng, N.Y.*, Aug. 1952, Vol. 71,

No. 8, p. 729.) Analysis and discussion of the manner in which the current waveform is affected by varying the circuit resistances, inductances or control voltage. Digest only; full paper to be published in *Trans. Amer. Inst. elect. Engrs*, 1952, Vol. 71.

621.316.729 **339**

A Synchronizing Circuit for Variable Input Voltages.—P. A. V. Thomas. (*Electronic Engng*, Nov. 1952, Vol. 24, No. 297, p. 509.) Description of a circuit suitable for use with a c.r.o.

621.316.86 **340**

Boroncarbon Resistor Characteristics.—G. Kende. (*Tele-Tech*, Aug. 1952, Vol. 11, No. 8, pp. 48–49, 75.) Further developments are described leading to the mass production of ½-W resistors with extremely stable characteristics. See also 583 and 2365 of 1951 (Grisdale et al.).

621.316.86 **341**

Shaping of Nonlinear-Resistor Characteristics.—J. J. Baruch. (*Proc. nat. Electronics Conf., Chicago*, 1951, Vol. 7, pp. 537–541; *Tele-Tech*, June 1952, Vol. 11, No. 6, pp. 42–43, 88.) Feedback circuits are described which enable a wide variety of characteristics to be obtained with a single resistive element.

621.316.86 : 537.312.092 **342**

Effect of Pressure on the Resistance of a Thermistor.—P. Tavernier & P. Prache. (*J. Phys. Radium*, July/Sept. 1952, Vol. 13, Nos. 7/9, pp. 423–426.) Measurements at constant temperatures from 30° to 70°C and pressures up to 5000 kg/cm² show that the relative diminution of the resistance of a thermistor for a given change of pressure is practically independent of temperature and is given by the formula $\Delta R/R_0 = -4{\cdot}6 \times 10^{-6} P$, P being expressed in kg/cm².

621.318.57 **343**

All-Triode Electronic Switch.—C. W. Spindler, Jr. (*Electronics*, Nov. 1952, Vol. 25, No. 11, pp. 172, 174.) The basis of the arrangement described is a gate circuit using two high-μ triodes cathode-coupled respectively to two high-transconductance triodes, the grids of the latter being coupled to the anodes of a multivibrator.

621.319.4 : 621.315.614.6 **344**

Metallized-Paper Capacitors.—H. Elsner. (*Bull. schweiz. elektrotech. Ver.*, 6th Sept. 1952, Vol. 43, No. 18, pp. 721–727. In German.) Review of the development, construction and characteristics of this type of capacitor, particularly those using impregnated paper. Test methods are noted.

621.319.4 : 621.315.614.64 **345**

High-Temperature Operation of Metallized-Paper Capacitors.—L. Kahn. (*Proc. nat. Electronics Conf., Chicago*, 1951, Vol. 7, pp. 561–567.) Discussion of results obtained with capacitors impregnated with aerolene, a solid polyester, which permits operation at 100°C without derating, and up to 125°C with a derating of 25%, the capacitance value at 125°C being 15% higher than at room temperature.

621.392.087.6 **346**

An Electronic Square-Law Circuit for Use with a Graphic Recorder.—M. J. Tucker. (*Electronic Engng*, Oct. 1952, Vol. 24, No. 296, pp. 466–468.) The curvature of valve characteristics is used to produce an output voltage proportional to the square of the input voltage. Circuit details are given of a mean-square-value meter suitable for graphic recording of the output.

621.392.5 : 534.321.9 : 534.133 **347**

Performance of Ultrasonic Vitreous Silica Delay Lines.—M. D. Fagen. (*Proc. nat. Electronics Conf., Chicago*, 1951, Vol. 7, pp. 380–389.) See 2462 of 1952.

621.392.5.018.75 **348**

The Synthesis of a Network to have a Sine-Squared Impulse Response.—W. E. Thomson. (*Proc. Instn elect. Engrs*, Part III, Nov. 1952, Vol. 99, No. 62, pp. 373–376.) The method of moments, of the 'mean moment' type used by Moss (619 of 1952), is applied to the problem of designing a network with an impulse response of prescribed form. The method is not applicable in all cases, but is particularly suitable for the design of a low-pass system with not too sharp a cut-off and not too oscillatory an impulse response. Calculation for the case of the sine-squared pulse results in design data for a ladder network of 3 inductors and 6 capacitors, with resistive terminations. The discrepancy between the impulse-response curve and the exact sine-square curve at no point exceeds 2% of the peak amplitude of the pulse.

621.392.52 : 518.4 **349**

New Graphical Methods for Analysis and Design.—W. Saraga. (*Wireless Engr*, Dec. 1952, Vol. 29, No. 351, p. 334.) Reply to comment by Schneider (2751 of 1952) on paper noted in 1546 of 1952 (Saraga & Fosgate).

621.392.52 : 621.3.015.3 **350**

The Transient Response of R.F. and I.F. Filters to a Wave Packet.—A. W. Gent. (*Proc. Instn elect. Engrs*, Part III, Nov. 1952, Vol. 99, No. 62, pp. 414–416.) Summary only. Analysis based on Fourier-integral transforms is applied to two particular circuits: (*a*) a single stage of tuned-anode coupling; (*b*) a single stage of tuned-transformer coupling. The analysis is valid for circuits of any bandwidth. Particular attention is paid to the build-up time of a transient, which for a band-pass network is usually assumed to be inversely proportional to the network bandwidth. The analysis shows that this assumption is correct for the tuned-anode coupling circuit if the ratio of the half-bandwidth to the resonance frequency is less than unity. For the tuned-transformer circuit, however, the rule does not hold good, since for a given bandwidth there are many possible transfer impedances, and hence transient responses. The rule should therefore only be applied to circuits to which its application is shown to be legitimate.

621.392.52.029.426 **351**

High-Q Low-Frequency Resonant Filters.—J. S. Brown & W. Thayer, Jr. (*Proc. nat. Electronics Conf., Chicago*, 1951, Vol. 7, pp. 92–96.) Two 30-c/s resonant filters are described in which a Q-factor > 1000 is obtained by application of positive feedback. Normal methods used for Q measurement are of little use on these circuits. A method based on the relation of Q to the transient response is described.

621.396.6 **352**

Printed Unit Assemblies for TV.—W. H. Hannahs & N. Stein. (*Tele-Tech*, June 1952, Vol. 11, No. 6, pp. 38–40 . . 120.) Etching and silk-screening techniques, and their suitability for the production of various circuit elements, are discussed. Experimental results are quoted which show that the performance of etched coils compares favourably with that of wire-wound coils.

621.396.6 **353**

Etched Circuits.—(*Wireless World*, Dec. 1952, Vol. 58, No. 12, p. 488.) A brief note on the Technograph system for producing printed circuits and components, with special reference to the production of mains transformers.

621.396.6 : 621.357.7 **354**

Printed Circuits for Home Radio Receivers.—E. Waverling. (*Electronics*, Nov. 1952, Vol. 25, No. 11, pp. 140–142.) Units for 5-valve superheterodyne sets are produced by plating conductors on to a plastic base in which holes have been punched previously. The walls of the holes are plated at the same time, thus providing connections and terminal points.

621.396.6.002.2 **355**

New Developments in the Auto-sembly Technique of Circuit Fabrication.—S. F. Danko. (*Proc. nat. Electronics Conf., Chicago*, 1951, Vol. 7, pp. 542–550.) Various applications of the technique previously described [2949 of 1951 (Danko & Lanzalotti)] are reviewed. New copper-faced plastics are suitable for production of equipment for operating temperatures up to 200°C. Use of a solder-resistant paint or lacquer enables joints only to be soldered in the solder-dip process. Typical examples of circuits and assemblies produced by this method are illustrated.

621.396.611.1 : 518.4 **356**

Graphical Analysis for Circuits containing Overdriven Vacuum Tubes.—R. J. Parent. (*Proc. nat. Electronics Conf., Chicago*, 1951, Vol. 7, pp. 263–274.) Methods of approach and graphical constructions for use in analysis of circuits such as those used for pulse forming and wave shaping are described, with applications to particular circuits.

621.396.611.21 **357**

Thickness Vibrations of Piezoelectric Crystal Plates.—R. Bechmann. (*Arch. elekt. Übertragung*, Sept. 1952, Vol. 6, No. 9, pp. 361–368.) Continuation of investigation noted in 150 of 1941. The retroaction occurring in piezo-electric processes modifies not only the modulus of elasticity but also the direction of motion. The influence of this secondary effect is studied and a complete theory of the mechanical-electrical oscillating system is developed for plates of infinite area. For plates of finite area the amplitude distribution becomes nonuniform; the effect of this modification is studied in relation to the equivalent circuit.

621.396.611.21 : 621.3.018.3 **358**

A Method of Analysis of Fundamental and Overtone Crystal-Oscillator Circuits.—F. G. R. Rockstuhl. (*Proc. Instn elect. Engrs*, Part III, Nov. 1952, Vol. 99, No. 62, pp. 377–388.) Use of the method of loci facilitates comparison between (*a*) the Pierce-Miller and (*b*) the Pierce-Colpitts type of crystal-oscillator circuit. Type (*a*) is much more suitable for harmonic oscillation and very high frequencies because it requires less mutual conductance. Type (*b*) is, under certain conditions, particularly suitable for frequency standards. Circuits with the crystal connected between anode and cathode have, under certain conditions, low power dissipation in the crystal. Conditions for frequency stability are analysed and a simple and accurate method of determining crystal parameters is described.

621.396.611.3 : 621.394/.395].44 **359**

Broad-Band Coupling Unit for Power-Line Carrier with Associated Potential Device.—J. A. Doremus, R. P. Crow & W. H. Freeman. (*Elect. Engng, N.Y.*, Aug. 1952, Vol. 71, No. 8, pp. 707–713.)

621.396.611.4 **360**

Some Perturbation Effects in Microwave Cavities operating in Degenerate Modes.—S. K. Chatterjee. (*J. Indian Inst. Sci.*, Section B, July 1952, Vol. 34, No. 3, pp. 77–87.) Theoretical investigation of the perturbation caused by introducing a metal rod into a cylindrical cavity operating in the companion modes TE_{018} and TM_{118}. The changes in Q-value and resonance frequency are different for the two modes. The magnitudes of these changes as dependent on the radius and depth of insertion of the rod are considered.

621.396.612.1 **361**

Precalculation of the Mains Loading in the Design of High-Frequency Generators using Quenched Sparks.—W. Besthorn. (*Elektrotech. Z., Edn A*, 1st Aug. 1952, Vol. 73, No. 15, pp. 482–484.) The power required to drive a h.f. generator of the air-blast quenched-spark type is determined from consideration of the generator equivalent circuit. Such generators are frequently used for h.f. inductive heating.

621.396.615.016.35 : 621.396.822 **362**

The Effect of Noise on the Frequency Stability of a Linear Oscillator.—R. M. Lerner. (*Proc. nat. Electronics Conf., Chicago*, 1951, Vol. 7, pp. 275–286.) The standard conditions for a sinusoidal oscillation are that the attenuation and net phase shift around the closed loop be zero. Random fluctuations are relied upon to start the oscillation. If the level of oscillation is to remain finite in the continued presence of noise, the oscillating loop must have some attenuation, and functions like a highly regenerative amplifier with a loop gain very nearly unity. Accordingly, the oscillator produces not a single frequency, but rather a narrow band of noise that causes instability in the magnitude and in the apparent frequency of the output. These instabilities are discussed for oscillators in which all elements are linear except for some slow-acting amplitude control. The bandwidth of the noisy oscillation can be predicted from easily measured system characteristics. Several methods of defining the frequency of the output are considered with special reference to precision measurements. In general the measured frequency departs from the zero-phase-shift criterion and is dependent on the measuring equipment. Methods of minimizing instabilities due to noise are investigated.

621.396.615.142.2 **363**

The Effect of Long Transmission Lines on Klystron Oscillators.—J. Cohn. (*Proc. nat. Electronics Conf., Chicago*, 1951, Vol. 7, pp. 46–58.) Discussion of effects occurring when the oscillator load is several wavelengths away from the valve. Equivalent circuits are applied to analysis of the f.m. distortion and of the discontinuities in the klystron characteristics. Experimental results are presented which corroborate the theory.

621.396.615.17.015.7 **364**

A Hard-Valve Pulse Generator.—D. A. Levell. (*Electronic Engng*, Nov. 1952, Vol. 24, No. 297, pp. 507–509.) Description, with circuit details, of a triggered generator producing pulses of width variable from 0·7 to 12·8 μs. Slight modifications result in (*a*) a free-running generator, (*b*) a triggered generator of 5-ms pulses which is easily converted to free running with a repetition period of 10 ms. Pulses of either polarity can be used for triggering.

621.396.645 **365**

A Design for a Constant-Volume Amplifier.—G. J. Pope. (*Electronic Engng*, Oct. 1952, Vol. 24, No. 296, pp. 464–465.) The so-called constant-volume amplifier is used extensively on overseas telephone circuits so that a reasonable modulation depth can be used without the risk of overmodulation. Circuit details are given of an amplifier which is simple to set up and reliable in operation and which uses a cathode-follower circuit as a variable impedance. The results obtained are comparable to those given by conventional networks using metal-rectifier bridge networks.

621.396.645 **366**

A Feedback-Pair Video Amplifier.—V. H. Attree. (*Electronic Engng*, Nov. 1952, Vol. 24, No. 297, pp. 504–506.) Details are given of a circuit with a gain of 100, frequency range 8 c/s–8 Mc/s, and a midband output linear up to 50 V r.m.s.

621.396.645 **367**

Cathode-Follower as High-Impedance Input Stage.—D. A. Bell & H. O. Berktay. (*Wireless Engr*, Dec. 1952, Vol. 29, No. 351, pp. 313–316.) If a cathode-follower is used as the first stage of an amplifier in order to raise the input impedance, the conductance of the grid-leak (between grid and cathode) may not be negligible compared with the conductance of the source (between grid and earth) from which the signal is derived. The noise performance under these conditions is examined, both in terms of the cathode-follower regarded as a 1 : 1 voltage device and in terms of the 'noise figure', which takes account of the difference between input and output impedances.

621.396.645 : 621.396.822 **368**

Amplifier Noise, particularly in the Audio-Frequency Range.—K. S. Nordby. (*Tech. Mitt. schweiz. Telegr.-Teleph.Verw.*, 1st June 1952, Vol. 30, No. 6, pp. 185–197.) Noise in input stages is investigated; Nyquist's formula is taken as starting point, and only simple mathematics is used. Noise in resistors is dealt with by the usual device of substituting an equivalent noise voltage source in series with a noise-free resistor. The input circuit of a capacitor microphone is considered particularly; its noise voltage is determined largely by the slope and position of the low-frequency flank of the response curve. Noise in oscillating circuits is associated with the damping resistance. Formulae are given for calculating the equivalent noise resistance of valves; for the same operating point, a valve produces much more noise in the a.f. range than at higher frequencies. The signal/noise ratio of a circuit with ideal input transformer is considered, and the condition for obtaining maximum sensitivity is derived.

621.396.645.37.024 **369**

D.C. Amplifiers with Low-Pass Feedback.—J. A. Colls. (*Wireless Engr*, Dec. 1952, Vol. 29, No. 351, pp. 321–325.) Brockelsby (1910 of 1949) and Mayr (3110 of 1949) have shown how to design a voltage amplifier of high stability and with a response curve of maximum flatness, but their method has the disadvantage that the amplifier must have a particular value of loop gain. If the loop gain is varied, the overall frequency response will be seriously affected and the amplifier may be unstable if used as an integrator or differentiator. The method is extended to cover the case of a d.c. amplifier with a low-pass feedback network. The gain of such an amplifier can be varied over a wide range without appreciable effect on the overall frequency response, so that it can be used as a stable differentiator or integrator. The output noise level may limit the field of application.

GENERAL PHYSICS

53.08 : 001.61 **370**

Representation of Experimental Results by Equations. Linearized Empirical Laws.—L. A. Sackmann. (*C. R. Acad. Sci., Paris*, 6th Oct. 1952, Vol. 235, No. 14, pp. 689–691.) An analytical method is discussed for determining the form of the equation representing the measurements of a dependent variable as a function of an independent variable; the accuracy with which values can hence be found for the numerical coefficients is examined.

53.08 : 001.61 **371**

Representation of Experimental Results by Equations. New Useful Formulae.—L. A. Sackmann. (*C. R. Acad. Sci., Paris*, 13th Oct. 1952, Vol. 235, No. 15, pp. 783–784.) Methods are outlined for determining the coefficients of equations fitting a series of observed values, weighted or not weighted.

535.37 : 539.2 **372**

Transfer and Transport of Energy by Resonance Processes in Luminescent Solids.—T. P. J. Botden. (*Philips Res. Rep.*, June 1952, Vol. 7, No. 3, pp. 197–235.) Experiment shows that the ratio between the efficiencies of activator and sensitizer fluorescence increases with increasing sensitizer concentration. This is at variance with theory. An explanation is given and a theory is developed that accounts for the temperature dependence of the energy transfer. Part I: 1882 of 1952.

535.42 **373**

The Uniqueness of the Solutions in the Rigorous Theory of Diffraction.—H. Hönl & A. W. Maue. (*Z. Phys.*, 19th Aug. 1952, Vol. 132, No. 5, pp. 569–578.) The solutions previously given by Hönl (2182 of 1952) not only satisfy the usual conditions, but also meet the requirement that no subsidiary wave fields be radiated from the edges of the aperture, so that the uniqueness of the solutions is established.

535.42 : 538.566 **374**

A Simplifying Technique in the Solution of a Class of Diffraction Problems.—D. S. Jones. (*Quart. J. Math.*, Sept. 1952, Vol. 3, No. 11, pp. 189–196.) Considerable simplification of the treatment of diffraction problems leading to Wiener-Hopf integral equations results from taking the transform before applying the boundary conditions. This is demonstrated by consideration of (*a*) the Sommerfeld problem for the semi-infinite plane, (*b*) the diffraction of small-amplitude sound waves by a semi-infinite rigid cylinder, (*c*) the diffraction of a plane e.m. wave by a finite waveguide, (*d*) a vector field.

535.767 : 535.88 **375**

New Direct-Vision Stereo-projection Screen.—W. W. Jennings & P. Vanet. (*J. Soc. Mot. Pict. Telev. Engrs*, July 1952, Vol. 59, No. 1, pp. 22–27.) Russian work on stereo-projection screens is briefly described and a more detailed account is given of a system developed in France by F. Savoye (see *Rev. Photographie Optique*, Feb. 1951, p. 23). This uses a rotating cone-shaped grill moving round the screen, thus enabling collective direct vision of stereoscopic pairs in either monochrome or colour.

537.291 **376**

Motion of Gaseous Ions in a Strong Electric Field: Part 2.—G. H. Wannier. (*Phys. Rev.*, 1st Sept. 1952, Vol. 87, No. 5, pp. 795–798.) The theory previously given for uniform-ion densities (97 of 1952) is extended to deal with nonuniform densities. Errata in the earlier paper are indicated.

537.311.3 : 538.63 **377**

Mechanism of Resistance Variation in a Magnetic Field.—A. Nedoluha & K. M. Koch. (*Z. Phys.*, 19th Aug. 1952, Vol. 132, No. 5, pp. 608–620.) A model with two layers having different resistances and resistivities is proposed to explain the Hall effect and the variation of resistance of a material subjected to an electric field.

537.311.31 : 538.639 **378**

Theory of the Electrical Conductivity of Metals in a Magnetic Field.—Yu. B. Rumer. (*Zh. eksp. teor. Fiz.*, Feb. 1952, Vol. 22, No. 2, pp. 214–222.) Formulae are derived for determining the resistance of metals in a

transverse and in a longitudinal magnetic field, taking into account the quantization of the movement of electrons in a magnetic field.

537.311.4 379

Theory of the Contact between a Metal and a Semiconductor for a Large Contact Potential Difference.—A. I. Gubanov. (*Zh. eksp. teor. Fiz.*, Feb. 1952, Vol. 22, No. 2, pp. 204–213.) The I/V characteristic for the contact between a metal and a semiconductor is calculated for the case when the contact potential difference is so great that the type of conduction of the semiconductor near the contact is altered from the electron to the hole type. The calculations cover the cases of plane, knife-edge and needle types of contact.

537.525 : 537.533.79 380

Determination of Electron Density and Collision Frequency in a Gaseous Discharge by Microwave Propagation Measurements.—L. Goldstein, M. A. Lampert & R. H. Geiger. (*Elect. Commun.*, Sept. 1952, Vol. 29, No. 3, pp. 243–245.) The gaseous discharge to be measured fills a section of waveguide several wavelengths long, and measurements are made of the absorption and phase shift of a low-power microwave signal passing through the discharge. Results are quoted for Ar at pressures respectively of 0·5 and 2·0 mm Hg.

537.525 : 621.385.2 381

Reliability of Probe Measurements in Hot Cathode Gas Diodes.—G. Wehner & G. Medicus. (*J. appl. Phys.*, Sept. 1952, Vol. 23, No. 9, pp. 1035–1046.) Erroneous results may be obtained due to the work function of the probe altering during the measurements. Particularly when investigating tubes with oxide cathodes, the measurement must be made immediately after cleaning the probe. In the experiments described, a c.r.o. plotter was used which took only some seconds to record the whole probe characteristic. In contrast to results obtained by other workers, no deviation from the Maxwellian velocity distribution of the plasma electrons was observed over a range of nearly four orders of magnitude of probe current.

537.533 : 538.566 382

Theory of the Propagation of Waves in an Electron Beam.—L. N. Loshakov. (*Zh. tekh. Fiz.*, Feb. 1952, Vol. 22, No. 2, pp. 193–202.) An approximate theory is developed for the propagation of e.m. waves in a waveguide filled with a dielectric, when an electron beam passes through it. It is assumed that electrons can move freely along the waveguide in the dielectric and that they form a beam completely filling it. With certain assumptions, the types and characteristics of the waves which can travel in such a system are determined for various conditions. The results obtained can be generalized so as to cover the case of an arbitrary transmission line.

537.533.1 : 538.691 383

The Motion of Electrons in the Field of a Uniformly Wound Toroid.—S. G. Nilsson. (*Ark. Fys.*, 16th Aug. 1952, Vol. 4, Part 4, pp. 347–351.) The focusing properties of the toroid are investigated theoretically in relation to beta-particle or other spectroscopes.

537.533.8 : 621.385.833 384

Secondary Electron Emission from Certain Metals under the Impact of Positive Lithium Ions.—G. Couchet. (*C. R. Acad. Sci., Paris*, 27th Oct. 1952, Vol. 235, No. 17, pp. 944–946.) An arrangement for measuring the emission is described and results are given for some metals used in electron microscopy.

537.562 : 533.15 : 551.510.535 385

The Relation between Electrical and Diffusion Currents.—M. H. Johnson. (*J. geophys. Res.*, Sept. 1952, Vol. 57, No. 3, pp. 405–412.) A linear relation is derived between (*a*) the electric current through a conducting gas in a magnetic field and (*b*) the currents due to diffusion of the charge carriers in the gas. From this relation the vertical displacements of the ionosphere E layer due to lunar effects are determined from the current system inferred from the lunar changes of the geomagnetic field. Both the amplitude and phase of the displacement are consistent with observations if it is assumed that the main lunar current flows in the lower part of the E layer, and that approximately equal numbers of ions and electrons are present at the point of observation.

537.562.001.11 386

Theory of the Plasma in a Rarefied Gas when the Current Strength varies.—V. L. Granovski. (*Zh. eksp. teor. Fiz.*, Jan. 1952, Vol. 22, No. 1, pp. 3–10.) General equations for relatively slow processes in a plasma are applied to the calculation of the concentration of electrons and ions when the strength of the current through the gas varies. The partial de-ionization of the gas when the current decreases, and the residual concentration of electrons and ions after the current ceases to flow, are determined.

538.26 387

Calculation of the Leakage Flux of the Pendent-Armature Relay.—J. W. Cohen & H. Grosser. (*Commun. News*, June 1952, Vol. 12, No. 4, pp. 125–131.) The magnetic conductivity of the space between core and yoke is determined by application of Southwell's relaxation method.

538.311 : 621.318.42 : 513.647.1 388

Investigation of Electromagnetic Waves Guided by Helical Conductors.—É. Roubine. (*Ann. Télécommun.*, May–Aug. 1952, Vol. 7, Nos. 5–8, pp. 206–216, 262–275 & 310–324.) Full theoretical analysis of the propagation of e.m. waves along helical conductors. Shorter versions of parts of the paper have previously been abstracted. The continuous-cylinder approximation (1350 and 2691 of 1951) gives a solution in good agreement with experimental results at frequencies sufficiently low, and with the action of a narrow-beam travelling-wave valve. The second method of analysis (2978 of 1951), based on the infinitely-thin-wire concept, leads to difficulties in calculation but has more general application and is apparently correct to the second order of approximation. Its application to delay lines is illustrated. Results obtained by the two methods are compared (1580 of 1952) and discussed with reference to experimental measurements.

538.56 : 535.212 : 621.396.677 389

Reflection of Microwaves from Metal-Plate Media.—J. J. Brady, M. D. Pearson & S. R. Peoples. (*J. appl. Phys.*, Sept. 1952, Vol. 23, No. 9, pp. 964–975.) Experiments were made, using frequencies in the 3-cm band, to verify the theory worked out by Lengyel (1879 of 1951). Waveguide assemblies of various depths were used, with the reflecting surfaces normal to the plates. For single-surface measurements the absorbing wedges described by Ruze & Young (1880 of 1951) were used. Phase and amplitude of the reflection coefficient were determined for angles of incidence 10°, 25° and 35° and for various ratios between plate separation and wavelength. Double-surface ('slab') measurements were also made, using assemblies of parallel plates instead of square waveguides.

538.566 : 517.942.82 390

The Propagation of the Wave Front in a Dispersive Medium.—M. Marziani. (*R. C. Accad. naz. Lincei*, June

1952, Vol. 12, No. 6, pp. 683–687.) The problem is investigated theoretically, by means of the Laplace transformation, for the general case of a plane e.m. wave in a homogeneous medium.

539.153 **391**

A Soluble Problem in Energy Bands.—J. C. Slater. (*Phys. Rev.*, 1st Sept. 1952, Vol. 87, No. 5, pp. 807–835.) "The problem of an electron moving in a periodic simple cubic potential of the form $\cos x + \cos y + \cos z$ is investigated, with particular attention to the nature of the wave functions, Wannier functions, degeneracy of overlapping bands, etc."

GEOPHYSICAL AND EXTRATERRESTRIAL PHENOMENA

522.1(54) : 551.510.535 **392**

Kodaikanal Observatory (1901–1950).—(*Indian J. Met. Geophys.*, April 1951, Vol. 2, No. 2, pp. 85–95.) An indication is given of the scope of the work carried on at this solar physics observatory, and of results so far achieved. Magnetic, meteorological and seismological observations are made, and the imminent commencement of ionosphere soundings is reported.

523.5 : 621.396.9 **393**

Double-Doppler Study of Meteoric Echoes.—L. A. Manning, O. G. Villard, Jr, & A. M. Peterson. (*J. geophys. Res.*, Sept. 1952, Vol. 57, No. 3, pp. 387–403.) Both the amplitude and phase of the signal returned from a meteor trail can be determined independently by use of a twin-channel Doppler system, details of which are presented. The technique has direct application to the determination of the drift of meteor trails, and to analysis of the spectra of echoes which exhibit amplitude fading.

523.746 "1951" **394**

Final Relative Sunspot-Numbers for 1951.—M. Waldmeier. (*J. geophys. Res.*, Sept. 1952, Vol. 57, No. 3, pp. 413–415.)

523.746"1952.04/.06" **395**

Provisional Sunspot-Numbers for April to June, 1952.—M. Waldmeier. (*J. geophys. Res.*, Sept. 1952, Vol. 57, No. 3, p. 419.)

523.8 : 621.396.822 : 550.385 **396**

Scintillation of Radio Stars during Aurorae and Magnetic Storms.—C. G. Little & A. Maxwell. (*J. atmos. terr. Phys.*, 1952, Vol. 2, No. 6, pp. 356–360.) During aurorae the rate of scintillation is four times that during normal conditions, probably as a consequence of a fourfold increase in the drift speed of the ionosphere irregularities causing the scintillations. More generally, the scintillation rate and the speed of the ionosphere irregularities are approximately proportional to the K index of geomagnetic activity.

550.38"1952.04/.06" **397**

Cheltenham Three-Hour-Range Indices *K* for April to June, 1952.—R. R. Bodle. (*J. geophys. Res.*, Sept. 1952, Vol. 57, No. 3, p. 419.)

550.38"1952.07/.08" **398**

Indices of Geomagnetic Activity of the Observatories Abinger, Eskdalemuir and Lerwick, July and August 1952.—(*J. atmos. terr. Phys.*, 1952, Vol. 2, No. 6, pp. 363–364.)

550.384.3 **399**

Secular Variation of the Magnetic Field at Colaba and Alibag.—S. K. Pramanik. (*J. geophys. Res.*, Sept. 1952, Vol. 57, No. 3, pp. 339–355.)

550.385"1952.01/.06" **400**

Principal Magnetic Storms [Jan.–June 1952].—(*J. geophys. Res.*, Sept. 1952, Vol. 57, No. 3, pp. 420–422.)

550.386 **401**

International Data on Magnetic Disturbances, First Quarter, 1952.—J. Bartels & J. Veldkamp. (*J. geophys. Res.*, Sept. 1952, Vol. 57, No. 3, pp. 416–418.)

551.510.5 : 546.17-1 **402**

Nitrogen in the Upper Atmosphere.—S. Deb. (*J. atmos. terr. Phys.*, 1952, Vol. 2, No. 6, pp. 309–323.) The probable distribution of atomic N is investigated theoretically; the method of calculation adopted is a modification of that used by Penndorf in investigating the dissociation of oxygen (2224 of 1949). Within the height range 70–170 km the predissociation mechanism suggested by Herzberg & Herzberg (*Nature, Lond.*, 1948, Vol. 161, p. 283) operates, while in the range 200–400 km a dissociative recombination suggested by Mitra (*Nature, Lond.*, 1951, Vol. 167, p. 897) is effective. In the lower region there is a sharp maximum in the distribution curve at about 90 km; in the upper region the concentration increases monotonically with height. The total number of N atoms in a vertical column of cross-section 1 cm² is calculated to be about 10^{16}.

551.510.53(54) **403**

Physical Properties of the Upper Atmosphere over India.—P. Koteswaram. (*Indian J. Met. Geophys.*, April 1951, Vol. 2, No. 2, pp. 101–112.) The height/temperature curve for Central India from ground up to 100 km has been constructed using data obtained from balloon measurements and sound-propagation experiments. The isothermal region found in the lower stratosphere over middle latitudes does not exist over India, the temperature increasing steadily above the tropopause. A comparison of data for India and for Europe indicates that summer east winds over North India extend up to about 30 km, with strong westerly winds aloft.

551.510.535 **404**

Dynamic Phenomena in the Ionosphere.—K. Bibl. (*C. R. Acad. Sci., Paris*, 6th Oct. 1952, Vol. 235, No. 14, pp. 734–736.) Records of F-layer height obtained with the rapid-sweep sounder at Freiburg show trace detail indicative of transient ionospheric variations. Various types of deformation of the trace are noted. These short-lived disturbances are nearly always propagated from a high level downwards.

551.510.535 : 523.32 **405**

An Effect of the Moon on the Median Height of the Ionosphere F_2 Layer.—R. Eyfrig. (*C. R. Acad. Sci., Paris*, 6th Oct. 1952, Vol. 235, No. 14, pp. 736–737.) At Huancayo, on the magnetic equator, there is a lunar effect amounting to several per cent on the median height of the F_2 layer during local summer; the effect is very much smaller in winter. At Freiburg, in a moderate latitude, the effect is extremely small if it exists at all.

551.510.535 : 523.745 **406**

The Solar Control of the E and F_1 Layers at High Latitudes.—J. C. W. Scott. (*J. geophys. Res.*, Sept. 1952, Vol. 57, No. 3, pp. 369–386.) The monthly-mean critical frequencies of the E and F_1 layers at high latitudes vary diurnally with solar zenith angle according to a modified Chapman law. Measurements of the seasonal, latitude, and solar-cycle phase dependence of the E-layer sensitivity to solar zenith angle and subsolar frequency are shown graphically. In the auroral zone, E-layer sensitivity to solar zenith angle is very low, but to the north of the zone it has the Chapman theoretical value.

551.510.535 : 523.8 : 621.396.822 **407**

Ionospheric Refraction of 81·5-Mc/s Radio Waves from Radio Stars.—F. G. Smith. (*J. atmos. terr. Phys.*, 1952, Vol. 2, No. 6, pp. 350–355.) An estimate of the total ionization of the F layer can be deduced from the refraction of radiation from radio stars caused by horizontal gradients of ionization occurring during normal diurnal variations in the layer. Interferometer measurements of the apparent positions of four radio stars are reported and the results are compared with calculated values based on ionospheric soundings; agreement is found if certain plausible assumptions are made regarding the vertical distribution of electrons about the maximum-concentration level of the F layer.

551.510.535 : 537.562 : 533.15 **408**

The Relation between Electrical and Diffusion Currents.—Johnson. (See 385.)

551.510.535 : 551.594.12 **409**

A Procedure for the Determination of the Vertical Distribution of the Electron Density in the Ionosphere.—J. M. Kelso. (*J. geophys. Res.*, Sept. 1952, Vol. 57, No. 3, pp. 357–367.) Description of a method based on application of the Gauss-Christoffel quadrature formula to the numerical integration of the well-known integral for 'true' reflection height as a function of group height. The earth's magnetic field and the effects of electron collisions are neglected, ray theory is assumed applicable and the electron-density/height curve is assumed to have no maxima or minima in the region considered.

551.510.535 : 621.396.11.029.51 **410**

A Method for Obtaining the Wave Solutions of Ionospherically Reflected Long Waves, including All Variables and Their Height Variation.—J. J. Gibbons & R. J. Nertney. (*J. geophys. Res.*, Sept. 1952, Vol. 57, No. 3, pp. 423–426.) Discussion on 137 of 1952.

LOCATION AND AIDS TO NAVIGATION

621.396.9 : 526.92] + 534.88 **411**

Optimum Signal Characteristics for Distance Measurement by Echoes.—L. Batchelder. (*Proc. nat. Electronics Conf., Chicago*, 1951, Vol. 7, pp. 29–38.) Carrier frequency, pulse duration and shape, properties of the medium, and target characteristics of radar and sonar systems are considered with particular reference to range and to measurement accuracy. Application is made to design of echo-sounding equipment.

621.396.932/.933].088 **412**

Dynamic Aspects of Errors in Radio Navigational Systems, particularly in cases of Fast-Moving Receivers and Transmitters.—H. Busignies. (*Elect. Commun.*, Sept. 1952, Vol. 29, No. 3, pp. 226–228.) A general discussion, including consideration of the effect of reflections from the surface of the earth. Accuracy can be effectively improved by sacrificing bandwidth for integration time. Errors due to reflections can be averaged out by radiating a frequency spectrum such that the various reflected components are received with random phases. Integration can then be applied over the frequency spectrum.

621.396.933 **413**

Glide-Slope Receiver.—R. C. Davis. (*Elect. Commun.*, Sept. 1952, Vol. 29, No. 3, pp. 219–225.) Description, with performance specification, block diagram, and some circuit details, of the new Type-154A receiver operating in the range 329·3–335·0 Mc/s. Twenty frequency-determining crystals are provided and may be selected individually by means of a bank of 11 relays. With the exception of the voltage-regulator valve, the 12 valves used are all of the 'reliable' type developed for airline use.

621.396.933.2 **414**

The Origin of Errors in Airborne M.F. Direction Finding.—J. H. Moon. (*Marconi Rev.*, 3rd Quarter 1952, Vol. 15, No. 106, pp. 97–113.) The importance of accurate ground calibration is emphasized, and a description is given of a combined compass base and d.f. calibration site where no reinforcing steel is used. Bearings taken in the air wander more than those obtained in ground tests; the difference is attributed to the deviation of the aircraft from the even-keel attitude. Operational tests indicate that an accuracy to within $\pm 2^\circ$ can be achieved if proper attention is paid to details. Correct design and location of the sense aerial are important if the d.f. indicator is to reverse immediately above a radio beacon.

MATERIALS AND SUBSIDIARY TECHNIQUES

535.215 + 535.343.2] : 546.22.19 **415**

Optical and Photoelectric Properties of Orpiment (As_2S_3).—G. I. Rekalova. (*Zh. tekh. Fiz.*, Jan. 1952, Vol. 22, No. 1, pp. 143–147.) Experiments were conducted to investigate the spectral distribution of absorption and of photocurrent in monocrystals of orpiment at the temperature of liquid air. Contrary to the normally observed disappearance of photoconductivity when idiochromatic crystals are illuminated by wavelengths in the absorption band, an increase in the photoconductivity was observed over an interval of more than 120 mμ from the long-wave boundary of the absorption band in the direction of the shorter waves. In the region of weak absorption, from 437 mμ, the law of quantum equivalent does not hold good, and the photocurrent in this region is proportional to the absorbed energy.

535.215 : 546.3-1-86-36 **416**

Optical Factors and Effective Depth in the Photoeffect of Antimony-Caesium Cathodes.—B. I. Dyatlovitskaya. (*Zh. tekh. Fiz.*, Jan. 1952, Vol. 22, No. 1, pp. 84–100.) The correlation between the optical properties of an Sb-Cs cathode and the photoeffect is made more definite, and from comparison of experimental and calculated data on the dependence of the photoeffect on the thickness of the layer, the character of the movement of excited photoelectrons inside the layer is established and the corresponding depth of emission of photoelectrons is determined. Certain peculiarities of the photoeffect of an Sb-Cs cathode are discussed on the basis of calculations of the absorbed energy.

535.343 : 546.24-1 : 548.55 **417**

Optical Polarization in Single Crystals of Tellurium.—J. J. Loferski. (*Phys. Rev.*, 1st Sept. 1952, Vol. 87, No. 5, pp. 905–906.) Measurements of the infrared transmission of Te crystals show that the position of the absorption edge, as well as the amount of radiation transmitted at longer wavelengths, depends markedly on the polarization of the incident light. The value of about 5·3 for the refractive index at 6 μ is somewhat higher than that found by Moss (2230 of 1952) for Te films.

535.37 : 546.472.84 : 537.29 **418**

Field-Dependent Fluorescence of Vitreous Zn_2SiO_4 Phosphor.—A. Bramley & J. E. Rosenthal. (*Phys. Rev.*, 15th Sept. 1952, Vol. 87, No. 6, p. 1125.) The lowest alternating voltage at which luminescence was observed varied from 100 V to 500 V, depending on the thickness and other parameters of the sample. At a fixed voltage the light output varied by a factor <5 in the frequency range 120 c/s–16 kc/s. See also 3439 of 1952 (Piper & Williams).

537.311.33 : 061.3 **419**

Seventh Conference on the Properties of Semiconductors (Kiev, 14th–21st October 1950).—(*Bull. Acad. Sci.*

U.R.S.S., sér. phys., Jan./Feb. & March/April 1952, Vol. 16, Nos. 1 & 2, pp. 5–138 & 139–232.) Full text of the papers given. See also 2728 of 1951.

537.311.33 : 537.568 **420**

Statistics of the Recombinations of Holes and Electrons.—W. Shockley & W. T. Read, Jr. (*Phys. Rev.*, 1st Sept. 1952, Vol. 87, No. 5, pp. 835–842.) The statistics of the recombination of holes and electrons in semiconductors are analysed on the basis of a model in which the recombination occurs through the mechanism of trapping. A trap is assumed to have an energy level in the energy gap so that its charge may have either of two values differing by one electronic charge. The dependence of lifetime of injected carriers upon initial conductivity and upon injected carrier density is discussed.

537.311.33 : 546.28-1 **421**

An Application of the Cellular Method to Silicon.—D. K. Holmes. (*Phys. Rev.*, 1st Sept. 1952, Vol. 87, No. 5, pp. 782–784.) The method used by Mullaney (1576 of 1945) is applied to the determination of the lowest energy limit of the conduction band and also the highest limit of the filled band; the effective mass of the conduction electrons is then deduced.

537.311.33 : 546.28-1 : 548.55 **422**

Silicon Single-Crystal Rods.—H. Kleinknecht. (*Naturwissenschaften*, Sept. 1952, Vol. 39, No. 17, pp. 400–401.) Single-crystal rods obtained from a melt in a quartz crucible by use of a seed crystal are described. The conductivity was *p*-type at the start of the crystal, then *n*-type nearly to the other end, finally reverting to *p*-type. The latter inversion is attributed to admixture of Al from the melt.

537.311.33 : 546.289-1 **423**

Temperature Dependence of the Backward Current of *p-n* Junctions in Germanium.—D. Geist & K. Seiler. (*Naturwissenschaften*, Sept. 1952, Vol. 39, No. 17, p. 401.) Rectifiers of the *p-n* type with Sb as donor and Al as acceptor impurities were investigated. *I/V* characteristics for temperatures of −70°, 27° and 60° C show a saturation current varying exponentially with temperature for low voltages. At high voltage (~ 100 V) the characteristics coalesce, the current increasing very rapidly.

537.311.33 : 546.289-1 : 535.343 : 535.61-15 **424**

New Infrared Absorption Bands in *p*-Type Germanium.—H. B. Briggs & R. C. Fletcher. (*Phys. Rev.*, 15th Sept. 1952, Vol. 87, No. 6, pp. 1130–1131.) Absorption bands at 3·4 μ and 4·7 μ are reported for Ge samples to which *p*-type impurities had been added.

537.311.33 : 546.289-1 : 537.565 **425**

Mobility of Electrons in Germanium.—P. P. Debye & E. M. Conwell. (*Phys. Rev.*, 15th Sept. 1952, Vol. 87, No. 6, pp. 1131–1132.) Measurements at room temperature on samples in various conductivity ranges have given higher mobilities than any previously found. In the range of resistivity for which drift mobility values are available, the results are in substantial agreement with those of Haynes & Shockley (1928 of 1951).

537.311.33 : 546.289-1 : 538.632 **426**

Interpretation of the Low-Temperature Hall Curve of a Degenerate Germanium Sample.—D. M. Finlayson, V. A. Johnson & F. M. Shipley. (*Phys. Rev.*, 15th Sept. 1952, Vol. 87, No. 6, pp. 1141–1142.) Measurements on *n*-type Sb-doped samples of Ge show a maximum of the Hall coefficient near 120° K, with a 20% drop from 116° K to 1·3° K. The results are discussed in relation to energy levels and carrier density.

537.311.33.001.8 **427**

Semiconductors and their Applications.—J. M. Moulon. (*Ann. Télécommun.*, Sept. 1952, Vol. 7, No. 9, pp. 364–374.) A brief review of modern theories of the conductivity and rectifying properties of semiconductors, with discussion of their applications in thermistors, various devices for physical and electrical measurements, and in transistrons of the point-contact and *p-n*-junction types.

539.234 : 533.5 **428**

Uniform Metallization of Surfaces by Thermal Evaporation, using a Single Emissive Source or Several Sources.—P. Prugne & P. Léger. (*J. Phys. Radium*, July/Sept. 1952, Vol. 13, Nos. 7/9, Supplement, pp. 129A–130A.) Description of a method which effectively realizes a circular emissive source by rotation of the target at 50 r.p.m., the source remaining stationary.

539.234 : 537.311.31 : 546.77 **429**

Protection of Thin Layers of Molybdenum by a Coating of SiO obtained by Evaporation in Vacuum.—C. Feldman. (*C. R. Acad. Sci., Paris*, 6th Oct. 1952, Vol. 235, No. 14, pp. 706–707.) The variation of resistivity with time is shown in graphs for Mo films with and without a SiO coating, in air at ordinary temperature, also for three similar coated Mo films kept respectively in vacuum, in dry air at ordinary temperature, and in dry air at the temperature of liquid N. The usefulness of the results for studying the oxidation of the Mo film is indicated.

539.234 : 546.59 **430**

Preparation and Properties of Thin Metal Films.—G. Ranc. (*Le Vide*, July/Sept. 1952, Vol. 7, Nos. 40/41, pp. 1211–1219.) A more detailed account of the work on evaporated gold films noted in 2739 of 1951 and 172 of 1952 (Colombani & Ranc).

546.217 : 621.317.335.3.029.64 **431**

Some Preliminary Studies of the Rapid Variations in the Index of Refraction of Atmospheric Air at Microwave Frequencies.—C. M. Crain & J. R. Gerhardt. (*Bull. Amer. met. Soc.*, Nov. 1950, Vol. 31, No. 9, pp. 330–335.) Report of results obtained with the equipment previously described [2565 of 1950 (Crain)]. A marked correspondence is noted between air temperature and moisture content, which largely determines the microwave refractive index.

546.431-1 : 532.72 **432**

Diffusion of Barium in Barium Oxide.—R. W. Redington. (*Phys. Rev.*, 15th Sept. 1952, Vol. 87, No. 6, pp. 1066–1073.) Diffusion of Ba in single crystals of BaO was measured in the temperature range 550–1520° K. Two diffusion processes were found, defects being responsible for both.

546.814 + 546.824 + 546.834]-3 : 621.317.011.5 **433**

Polarization and Dielectric Losses of Zirconates, Stannates and Certain Titanates of Bivalent Metals.—G. A. Smolenski. (*Zh. tekh. Fiz.*, Jan. 1952, Vol. 22, No. 1, pp. 3–11.)

549.514.63 : 548.55 : [535 + 537 **434**

Electrical and Optical Properties of Rutile Single Crystals.—D. C. Cronemeyer. (*Phys. Rev.*, 1st Sept. 1952, Vol. 87, No. 5, pp. 876–886.)

621.3.014.12 : 621.3.012.3 **435**

Universal Skin-Effect Chart for Conducting Materials.—H. A. Wheeler. (*Electronics*, Nov. 1952, Vol. 25, No. 11, pp. 152–154.) Formulae and a chart are given for finding the depth of penetration of current in some metals and solutions (including sea water) and in ground, at frequencies from 1 c/s to 1 000 kMc/s.

621.3.042.156 436

Magnetic-Powder Cores for Military Communication Equipment.—E. Both. (*Tele-Tech*, Aug. 1952, Vol. 11, No. 8, pp. 36–38 . . 105.) Discussion of core requirements, characteristics and shortcomings of present-day materials, and suitable tests of stability under severe conditions regarding temperature, humidity, etc.

621.314.632 437

Effect of Minority Carriers on the Breakdown of Point-Contact Rectifiers.—E. Billig. (*Phys. Rev.*, 15th Sept. 1952, Vol. 87, No. 6, pp. 1060–1061.) "On the application of short high-voltage pulses to point-contact rectifiers in the inverse direction, thermal instability is observed. Intrinsic conduction due to the thermal generation of electron-hole pairs and the subsequent passage of minority carriers (which are not affected by the potential barrier) is suggested as the cause of electrical breakdown."

621.315.612 : 621.315.62 438

The Properties of Semiconducting Ceramic Glaze.—D. H. Lucas. (*Brit. J. appl. Phys.*, Sept. 1952, Vol. 3, No. 9, pp. 293–296.) Further investigations were made of the glazes previously described by Forrest (1061 of 1948). Surface resistivity and contact resistance were measured over the temperature range −177° to +110°C. Rectification experiments and thermoelectric-power measurements indicate that the glazes are *n*-type semiconductors. Observed deterioration in service is attributed to electrolytic corrosion at the interface with surface films of water.

621.315.612.4 : 537.315.6 439

Potential Distribution in Barium Metatitanate and Other Ceramic Dielectrics.—E. V. Singakov & B. K. Chernyi. (*Zh. tekh. Fiz.*, Feb. 1952, Vol. 22, No. 2, pp. 265–267.) In investigations of the electrical conductivity of the titanates of metals of the second group, a fall of current with time is observed. In order to establish the cause of this phenomenon, the potential distribution in polycrystalline samples of TiO_2, (Ba-Sr)TiO_3 and $BaTiO_3$ was determined. The potential distribution in all the samples investigated remains linear for a wide range of temperatures and does not depend on the time during which the sample remains in an electric field. The fall of current is probably due to the presence of inhomogeneities uniformly distributed in the volume of the dielectric. In the case of barium metatitanate and (Ba-Sr)TiO_3, the formation of local volume charges may also be partly responsible for this phenomenon.

621.315.616 : 621.319.4 440

Polyethylene Terephthalate as a Capacitor Dielectric.—M. C. Wooley, G. T. Kohman & W. McMahon. (*Elect. Engng, N.Y.*, Aug. 1952, Vol. 71, No. 8, pp. 715–717.) An account of the properties which make this material, also known as 'mylar', particularly suitable as a capacitor dielectric. See also 667 of 1951 (Reddish).

621.396.611.21 441

Some Notes on the Design and Application of Quartz Crystals.—R. A. Spears. (*Strowger J.*, July 1952, Vol. 8, No. 3, pp. 99–105.) Temperature characteristics of plates of different cuts are discussed and flexure types of crystal for frequencies from 50 kc/s downwards are described. The relation between surface displacement and aging effect is considered briefly and typical crystal units, with dimensions and operating frequencies and temperatures, are illustrated.

621.396.611.21 : 549.514.51 : 532.111 442

Piezoelectric Resonance of Quartz up to 5 000 atm.—J. P. Pérez & P. Johannin. (*J. Phys. Radium*, July/Sept. 1952, Vol. 13, Nos. 7/9, pp. 428–429.) Experiments with a Y-cut crystal, immersed in petroleum ether and executing transverse oscillations parallel to the x direction (initial frequency 3·265 Mc/s), show that the frequency decreases linearly with increasing hydrostatic pressure, the decrease being 3·1 parts in 10^6 per kg/cm^2. See also 1350 of 1952 (Michels & Pérez).

666.1 : 621.317.374 443

Some Experiments and Theories on the Power Factor of Glasses as a Function of their Composition: Part 3.—J. M. Stevels. (*Philips Res. Rep.*, June 1952, Vol. 7, No. 3, pp. 161–168.) An investigation of borosilicate glasses at frequencies of 1·5 Mc/s and 24 kMc/s. Part 2: 3031 of 1951.

MATHEMATICS

517.65 : 621.396.11 444

A Table of $\sqrt{(\frac{1}{2}\pi)}e^{\frac{1}{4}i\pi\rho^2}\int_{\rho}^{\infty} e^{\frac{1}{2}i\pi\lambda^2}\,d\lambda$ for Complex Values of ρ.—P. C. Clemmow & C. M. Munford. (*Phil. Trans. A*, 16th Sept. 1952, Vol. 245, No. 895, pp. 189–211.) "In the theory of wave propagation the above function has applications for which ρ may be complex within a certain range of argument. Tables of the real and imaginary parts of the function are given to four decimal places, for values of $|\rho|$ from 0 to 0·80 at intervals of 0·01, and for values of arg ρ from 0° to 45° at intervals of 1°."

519.24 : 621.396.822 445

On the Theory of Prediction of Nonstationary Stochastic Processes.—R. C. Davis. (*J. appl. Phys.*, Sept. 1952, Vol. 23, No. 9, pp. 1047–1053.) "We consider the following problem of prediction: During a finite time interval T the real valued function $S(t) + N(t)$ is observed, in which $S(t)$ is a signal and $N(t)$ is a linearly superimposed noise disturbance. The problem is to predict the value of a given linear functional of $S(t)$, the predictor formula having certain preassigned 'optimum properties' among a certain class of predictors."

681.142 446

The Whirlwind-I Computer.—R. R. Everett. (*Elect. Engng, N.Y.*, Aug. 1952, Vol. 71, No. 8, pp. 681–686.) Description of a high-speed digital computer developed at the M.I.T., mainly for applications to control and simulation; an indication is given of some of the problems actually handled by the machine.

681.142 447

The Physical Realization of an Electronic Digital Computor.—A. D. Booth. (*Electronic Engng*, Oct. 1952, Vol. 24, No. 296, pp. 442–445.) Continuation of previous papers (3179 of 1949 and 1184 of 1951), giving descriptions of (*a*) the multiple-shift instruction methods, (*b*) the multipher, (*c*) the function table, (*d*) the control system. Input-output devices for computers under development in the Birkbeck College research laboratory will be considered in the final article of this series.

681.142 448

Diode Limiters simulate Mechanical Phenomena.—C. D. Morrill & R. V. Baum. (*Electronics*, Nov. 1952, Vol. 25, No. 11, pp. 122–126.) In analogue computers for simulating nonlinear systems characterized by discrete operating states, diodes are preferred to relays on account of their higher speed. Basic circuits are described and applications are shown to the study of cam-operated engine valves and the simulation of static and coulomb friction.

681.142 **449**

Multi-stable Magnetic Memory Systems.—J. D. Goodell & T. Lode. (*Proc. nat. Electronics Conf., Chicago*, 1951, Vol. 7, pp. 378–379.) See 1949 of 1952.

681.142 **450**

A High-Precision Analog-to-Digital Converter.—B. Lippel. (*Proc. nat. Electronics Conf., Chicago*, 1951, Vol. 7, pp.206–215.)

681.142 **451**

A Precise Electronic Function Generator.—C. N. Pederson, A. A. Gerlach & R. E. Zenner. (*Proc. nat. Electronics Conf., Chicago*, 1951, Vol. 7, pp. 216–227.)

681.142 **452**

Photoformer Design and Performance.—E. J. Hancock. (*Proc. nat. Electronics Conf., Chicago*, 1951, Vol. 7, pp. 228–234.)

681.142 : 519.272.119 **453**

An Analogue Electronic Correlator.—J. F. Reintjes. (*Proc. nat. Electronics Conf., Chicago*, 1951, Vol. 7, pp. 390–400.) Description of equipment providing up to 110 points on the correlation curve of signals with frequency components in the range 500 c/s–100 kc/s. Operation is based on the principle of discrete sampling, in pairs, of the input signal at periodic intervals. The delay, multiplication, and integration processes involved are carried out, for each pair of samples, by use of pulse techniques.

681.142 : 621.385.5 **454**

Germanium Photodiodes read Computer Tapes.—L. Packer & W. J. Wray, Jr. (*Electronics*, Nov. 1952, Vol. 25, No. 11, pp. 150–151.) A digital-computer input arrangement using Ge photodiodes of diameter 0·080 in. mounted six abreast above 6-channel tape enables up to 1 000 characters/sec to be read. A representative value of peak signal voltage from a 1N77 photodiode is 1·75 V. Plug-in amplifier units associated with the photocells are described.

MEASUREMENTS AND TEST GEAR

531.761 : 537.525.4 **455**

Electronic Spark Timing Device.—Á. Bardócz & Á. Kemény. (*Acta tech. Acad. Sci. hungaricae*, 1952, Vol. 3, Nos. 3–4, pp. 389–392. In English.) A variable-frequency multivibrator controls the rate of the periodic discharge of a capacitor through a thyratron. The discharge current passes through the primary of a Tesla transformer which gives sparks that are used to produce time marks on oscillograms. The spark recurrence frequency can be varied from the mains frequency to that of any subharmonic.

621.3.018.4(083.74) **456**

Industrial Frequency Standard.—H. W. Kline. (*Electronics*, Nov. 1952, Vol. 25, No. 11, pp. 130–131.) A 1-Mc/s frequency standard is obtained by means of an oscillator-divider locked to the 5-Mc/s carrier from WWV, using a tuned-r.f. receiver with input filter and clipper to eliminate the effect of noise. Lower or higher frequencies for laboratory use are obtained by means of multivibrators.

621.317 **457**

Techniques in the Measurement of Several Components.—I. Bady. (*Proc. nat. Electronics Conf., Chicago*, 1951, Vol. 7, pp. 551–560.) Methods are described for measuring (*a*) temperature coefficients of a large number of capacitors, (*b*) resistance and capacitance of resistors from 300 Ω to 1 MΩ over the range 100–400 Mc/s, (*c*) transmission unbalance of r.f. cable over the range 1–160 Mc/s.

621.317.323.012.3 : 621.392.26 **458**

Charts for Coaxial-Line Probe Measurements.—P. H. Smith. (*Proc. nat. Electronics Conf., Chicago*, 1951, Vol. 7, pp. 191–203.) Charts are provided for evaluating the impedance, voltage s.w.r., etc., along a r.f. transmission line from probe measurements of relative current or voltage at three points along the line with spacings known in terms of wavelength.

621.317.33.028.3 **459**

Measurement of Resistances above 10^{12} Ω.—K. H. Winterling. (*Arch. tech. Messen*, Aug. & Oct. 1952, Nos. 199 & 201, pp. 171–174 & 221–224.) Review of galvanometer and electrometer methods, including bridge methods and capacitor charge or discharge methods.

621.317.334 : 621.317.733 **460**

The Advantages of the Mutual-Inductance Bridge for Measurements of Ferromagnetic Cores.—H. Wilde. (*Arch. elekt. Übertragung*, Sept. 1952, Vol. 6, No. 9, pp. 354–360.) Analysis is given for the mutual-inductance bridge circuit (see also 196 of 1952). To avoid magnetic leakage the core is wound with coaxial cable of overall diameter 0·6 mm, the outer conductor forming the primary winding and the inner conductor the secondary. The influence of cable capacitance and of the error angle of the bridge is calculated and discussed. The frequency range is 1 c/s–10 Mc/s for the particular cable used.

621.317.335.029.63/.64 **461**

The Determination of Complex Dielectric Constants of Absorptive Liquids by Microwave Interferometry.—F. H. Branin, Jr. (*J. appl. Phys.*, Sept. 1952, Vol. 23, No. 9, pp. 990–997.) Measurements are made by means of a probe travelling along a slotted coaxial line filled with the dielectric liquid. Using a travelling-wave method, absolute measurements of wavelength and absorption index are made simultaneously and from them the dielectric constant is computed. Alternatively a standing-wave method can be used, in which case the absorption index is found graphically from the power s.w.r. For low-loss media a simplified standing-wave method can be used, in which the absorption index is found from the widths of successive minima of the standing wave.

621.317.336 : 621.392.26 **462**

Three-Probe Method of Impedance Measurement.—W. J. Duffin. (*Wireless Engr*, Dec. 1952, Vol. 29, No. 351, pp. 317–320.) Measurements of the s.w.r. in a waveguide are usually effected by means of a slotted section with a travelling probe. The use of three fixed probes, inserted through very small apertures in the waveguide walls, minimizes some sources of error, and considerably reduces the time required for a set of readings. The probe separations are $\lambda_g/8$, where λ_g is the wavelength in the waveguide, this separation giving a simple expression for the load impedance. Suitable apparatus is described and the method of calibration outlined.

621.317.336.029.64 : 537.52 **463**

Methods of Measuring the Properties of Ionized Gases at High Frequencies: Part 3—Measurement of Discharge Admittance and Electron Density.—D. J. Rose & S. C. Brown. (*J. appl. Phys.*, Sept. 1952, Vol. 23, No. 9, pp. 1028–1032.) Methods applicable to discharges in both high-Q and low-Q resonant cavities are described. An equivalent-circuit representation of the system is used which is valid as long as the presence of the discharge only slightly modifies the resonance frequency of the cavity. Part 2: 3489 of 1952.

621.317.337 : 621.396.611.2 **464**

High-Q Measurement.—W. J. Spaven. (*Electronics*, Nov. 1952, Vol. 25, No. 11, p. 166.) For values of $Q > 1\,000$ the value is determined by pulse excitation of the resonant circuit. A chart is provided for use in solving the equation giving Q in terms of the observed decrement of the oscillation.

621.317.337 : 621.396.611.4 **465**

A Sweep-Frequency Method of Q Measurement for Single-Ended Resonators.—E. D. Reed. (*Proc. nat. Electronics Conf., Chicago*, 1951, Vol. 7, pp. 162–172.) A method is described in which an oscillographic display of reflected power and incident power as functions of frequency is used to determine the internal and external Q of a cavity resonator. The Q of the cavity when loaded only by its own losses is termed the internal Q, the external Q applying to the cavity (considered lossless) loaded only by a matched transmission line. The method avoids the point-by-point determination of voltage s.w.r. necessary in methods hitherto used and can give rapid and accurate results.

621.317.34 **466**

Ratio Meter measures Reflection Coefficient.—L. A. Rosenthal, J. L. Potter & G. M. Badoyannis. (*Electronics*, Nov. 1952, Vol. 25, No. 11, pp. 136–139.) An arrangement is described in which two circuits, each comprising an amplifier and rectifier, are connected respectively to the two coils of a ratio meter, details of which are given. When measuring the reflection coefficient of h.f. transmission systems, signals proportional respectively to the incident and reflected waves are fed to the two circuits, and their modulation components are compared by the ratio meter, which can be calibrated in terms of reflection coefficient or voltage s.w.r. The arrangement is suitable for permanent installation in a h.f. transmission line.

621.317.341 : 621.392.21 **467**

A Simplified Method for Measuring the Attenuation of Balanced Transmission Lines.—R. C. Powell. (*Proc. nat. Electronics Conf., Chicago*, 1951, Vol. 7, pp. 287–290.) Limitations of methods normally used for measuring the attenuation of coaxial and shielded lines, when used for measurements on unshielded balanced lines, are reviewed. A method suitable for measuring the attenuation of unshielded lines to within 1% is described.

621.317.343.3 : 621.392.26 **468**

A Recording Broad-Band Waveguide Reflectometer.—A. L. Witten & R. E. Henning. (*Proc. nat. Electronics Conf., Chicago*, 1951, Vol. 7, pp. 173–180.) Description of equipment which records on a chart the reflection coefficient of a circuit component under test over the frequency band 4·25–6·0 kMc/s. The energy reflected by the test item is isolated by means of a specially designed high-directivity coupler. Barretter detection, followed by narrow-band a.f. amplification, is used to ensure square-law detection and constant detection sensitivity. A circuit deriving the square-root of the amplifier output voltage furnishes direct-reading chart indications of reflection coefficient.

621.317.35 : 621.396.619.11 : 373.62 **469**

Mechanical Synthesis of the Amplitude-Modulated Wave.—A. M. Hardie. (*Wireless Engr*, Dec. 1952, Vol. 29, No. 351, pp. 326–333.) Description of demonstration apparatus, constructed almost entirely from standard Meccano parts, for synthesis of an a.m. wave from three components with any relative amplitudes and phases.

621.317.35 : 621.396.619.16 **470**

Narrow-Band Spectrum Analysis of a Pulse-Position-Modulated Signal.—L. H. Lloyd. (*Proc. nat. Electronics Conf., Chicago*, 1951, Vol. 7, pp. 291–298.) Investigation of the capabilities and limitations of the sound spectrograph for obtaining relative frequency and position data from signals consisting of pairs of short pulses.

621.317.4 : 621.3.042.143 **471**

Magnetic-Amplifier Gapless-Core Tests.—J. R. Conrath. (*Electronics*, Nov. 1952, Vol. 25, No. 11, pp. 119–121.) A production test method is described in which the core is subjected to conditions similar to those encountered in operation. Windings for test purposes are obtained by passing a multipin plug through the core window and into a socket.

621.317.41 **472**

Method for Determining Magnetic Moments and for Measuring Susceptibilities and Permeabilities.—S. J. Barnett. (*J. appl. Phys.*, Sept. 1952, Vol. 23, No. 9, pp. 975–976.) Two similar solenoids A and B, connected in series-opposition through a measuring circuit, are arranged within a third solenoid producing a uniform field. The specimen is first placed within A and then moved quickly to B; from the resulting galvanometer throw the susceptibility is found directly. As compared with the permeameter method this method has the advantage, when testing materials of low permeability, of giving the difference between the permeability of the specimen and that of air, rather than the ratio between the two.

621.317.7.087.6 **473**

Continuous Recorder Keep-Alive Circuit.—R. L. Ives. (*Electronics*, Nov. 1952, Vol. 25, No. 11, pp. 161–163.) The performance of a pen recorder is improved by injecting an auxiliary 10-c/s signal into the system to keep the pens in constant motion. A circuit comprising multivibrator with four independent cathode-follower outputs for producing this signal is described.

621.317.72 : 621.316.722.4 **474**

Precision Megohm Ratio Unit for High Voltage Measurements.—J. N. Harris. (*Rev. sci. Instrum.*, Aug. 1952, Vol. 23, No. 8, pp. 409–413.) Description of the construction of a ratio box consisting of 100 10-kΩ manganin units in an oil bath maintained at 33°C, and capable of continuous operation at voltages up to 5 kV.

621.317.723 : 621.314.58 **475**

Theory of the Vibrating Condenser Converter and Application to Contact Potential Measurement.—J. R. Anderson & A. E. Alexander. (*Aust. J. appl. Sci.*, Sept. 1952, Vol. 3, No. 3, pp. 201–209.) Analysis indicates that, provided the load impedance is large compared with that of the capacitor, the harmonic content of the a.c. signal generated is small even for large changes of capacitance. The magnitude of the generated signal decreases as the load impedance decreases.

621.317.729 : 537.291 **476**

Automatic Tracer for Electron Trajectories.—F. Cassanas & P. Barchewitz. (*J. Phys. Radium*, July/Sept. 1952, Vol. 13, Nos. 7/9, Supplement, pp. 73A–83A.) Theory and description of electrolyte-tank equipment producing plane trajectories, with typical examples of its application.

621.317.73.029.55/.62 **477**

The Reflectometer for Measurements in the Short-Wave Range.—J. Grosskopf. (*Fernmeldetech. Z.*, July 1952, Vol. 5, No. 7, pp. 307–313.) Theory is given for a new type of directional coupler consisting of a stretched wire aerial arranged parallel to and between the conductors of a coaxial line, and terminated at both ends by its charac-

teristic impedance. The useful frequency range is from 10 to 300 Mc/s. Details are given of construction and performance.

621.317.73.029.62/.63 **478**

Impedance-Measuring Equipment for the 50–500-Mc/s Range.—J. E. Houldin. (*Proc. Instn elect. Engrs*, Part III, Nov. 1952, Vol. 99, No. 62, pp. 389–399.) Description of equipment for comparison of the modulus of an unknown impedance with that of a standard impedance consisting of a 100-Ω 0·1-W resistor with constant and minimum length of lead. From measurements of (*a*) the resonance impedance of an oscillatory circuit without and with the unknown impedance in parallel, (*b*) the impedance of a capacitor without and with the unknown in parallel, both the resistive and reactive components of the unknown impedance can be determined. Simplification of the general method is possible for several important cases. Typical results for high-value admittances, low-, medium-, and high-value conductances, and reactances of short-circuited transmission lines, are given.

621.317.733 **479**

The Wien Bridge and Some Applications.—C. F. Brockelsby. (*Electronic Engng*, Oct. 1952, Vol. 24, No. 296, pp. 450–453.) Analysis of the characteristics of the Wien bridge and discussion of its application to distortion measurement, wave analysis, and stabilization of the frequency of an oscillator.

621.317.735 **480**

An Electronic High-Voltage Insulation Tester.—L. R. Hulls & K. A. Mackenzie. (*Electronic Engng*, Nov. 1952, Vol. 24, No. 297, pp. 500–503.) Description, with detailed circuit diagram, of equipment providing a voltage continuously variable from 500 V to 10 kV d.c., together with means for measuring resistance values up to $2{\cdot}5 \times 10^{11}\Omega$, and an aural indication of the a.c. component of leakage or ionization current through the test specimen.

621.317.738.029.62 **481**

An Instrument for Dielectric Measurements in the Frequency Range 100–300 Mc/s.—D. L. Hollway & G. J. A. Cassidy. (*Proc. Instn elect. Engrs*, Part III, Nov. 1952, Vol. 99, No. 62, pp. 364–372.) Description of a short-circuited coaxial line of adjustable length, permitting measurements at different frequencies. The line is terminated by a parallel-plate capacitor with a disk sample of the material under test as dielectric. All measurements are based on a.f. calibrations of the measurement capacitors. Frequency corrections are analysed and possible errors discussed.

621.317.75 **482**

The Monitoring of High-Speed Waveforms.—J. G. McQueen. (*Electronic Engng*, Oct. 1952, Vol. 24, No. 296, pp. 436–441.) Description of Metropolitan-Vickers Type-500 equipment designed for observation of recurrent waveforms having frequency components up to 300 Mc/s. The recurrence rate should preferably be >100/sec. Waveforms with amplitudes as low as 0·1 V are displayed without distortion and two concurrent waveforms can be viewed simultaneously. Loading of the circuit producing the waveform is negligible. The waveform voltage is not used to deflect the beam in a c.r. tube, but is applied to a circuit capable of measuring its instantaneous amplitude at a selected point of the waveform. Each measurement is used to derive one *y* co-ordinate of a graph of the waveform and each coordinate persists for a considerable fraction of the recurrence period. The graph is traced relatively slowly by slightly changing the position of the selected point along the waveform at each recurrence. The *x* coordinates of the graph are produced by a deflection synchronized with the position of each selected point. The equipment can be used either with or without its additional anti-jitter unit. Applications to investigation of the build-up of oscillations in a magnetron, break-through in a t.r. switch to which a magnetron output is applied, build-up of a pulsed 150-Mc/s oscillator, and waveforms associated with a blocking oscillator, are illustrated.

621.317.772 **483**

A Precision Phase Comparator for Use at Low Radio Frequencies.—B. G. Pressey, C. S. Fowler & R. W. Mason. (*Proc. Instn elect. Engrs*, Part III, Nov. 1952, Vol. 99, No. 62, pp. 413–414.) Summary only. A calibrated phase shifter, such as an inductive goniometer, is connected in turn to the two c.w. sources whose phase difference is required, and adjusted with reference to an auxiliary source of the same frequency so as to obtain a convenient pattern, such as a straight line, on the screen of a c.r.o. The difference between the successive goniometer settings then gives the required phase difference. Refinements of the method, resulting in increased accuracy of measurement, are described in detail. Modifications enabling the equipment to be used at any one frequency in the range 30 kc/s–3 Mc/s, or over a range of frequencies, are suggested.

621.317.794.029.5 **484**

A Simple Bolometer for Dissipation Measurements.—V. J. Tyler. (*Marconi Rev.*, 3rd Quarter 1952, Vol. 15, No. 106, pp. 114–117.) Description of an instrument constructed from small squares of Cu foil, each tinned on one side and painted matt black on the other, arranged in a frame with adjacent squares facing in opposite directions, and with alternate Cu and eureka connections. Direct measurements can be made of the power dissipated by the anode of a small valve.

621.396.615 **485**

Two-Range Test Oscillator.—H. B. Dent. (*Wireless World*, Dec. 1952, Vol. 58, No. 12, pp. 508–511.) A compact unit is obtained by using a double-triode valve with the two sections functioning as separate oscillators, e.g. in the 100-Mc/s and 10-Mc/s bands respectively. The desired range is selected by switching the h.v. supply to the appropriate anode. Modulation voltage is applied across a common resistor to which the two grid leaks are connected. Design details and component values are given.

621.396.615.029.62/.63 **486**

Wide-Band Sweep Generator for V.H.F. & U.H.F. TV.—H. A. Finke & F. Blecher. (*Tele-Tech*, Aug. 1952, Vol. 11, No. 8, pp. 52–54, 75.) Description of a generator covering the range 35–900 Mc/s. Tuning is effected by means of a variable shorted transmission line from 900 to 150 Mc/s and by a variable inductor down to 35 Mc/s. Capacitor plates mounted at the end of a vibrating reed provide a frequency sweep of over 30 Mc/s in the u.h.f. range.

621.396.615.14 : 621.317.75 **487**

A Sweep-Frequency Oscillator for the U.H.F. Television Band.—J. A. Cornell & J. F. Sterner. (*Proc. nat. Electronics Conf., Chicago*, 1951, Vol. 7, pp. 433–439.) See 2285 of 1952.

621.396.615.17.015.7 **488**

Simple Pulse Generator for the Study and Testing of Amplifier, Selector and Counter Circuits, as well as Delay Lines.—A. Fréon & A. Martin. (*J. Phys. Radium*, July/Sept. 1952, Vol. 13, Nos. 7/9, p. 427.) Outline description of equipment using a mains-fed rectifier with a polarized relay for periodic charging and discharging of a capacitor. The discharge takes place through a resistor, the pulse

voltage across which is adjustable by means of a potentiometer across the output terminals of the rectifier. Pulse duration is variable from 1 ms to about 0·5 μs; recurrence frequency is that of the mains.

621.396.615.17.015.7 : 681.142 **489**

Test Pulse Generator for Digital Computers.—A. A. Gerlach. (*Electronics*, Nov. 1952, Vol. 25, No. 11, pp. 158–160.) Description of a generator which can be arranged to give a wide variety of random pulse outputs. Pulse duration is variable from about 2 to 40 μs, and amplitude up to about 60 V. Gate circuits and multivibrators are constructed as plug-in units. Pulses as short as 0·1 μs are obtained by using blocking-oscillator output circuits in place of cathode followers.

OTHER APPLICATIONS OF RADIO AND ELECTRONICS

531.784 : 538.31 **490**

Electric Micro-dynamometer.—T. Heim. (*Microtecnic*, 1952, Vol. 6, No. 4, pp. 197–208.) Description of an instrument with nine ranges, for torque measurements from about 10^{-4} to 3 g.cm. The torque to be measured is balanced by varying the current through a coil which can rotate in a radial magnetic field, as in a moving-coil galvanometer.

534.15 + 539.431] : 629.135 **491**

Aircraft-Vibration Research.—D. M. Corke. (*Electronic Engng*, Nov. 1952, Vol. 24, No. 297, pp. 518–522.) An outline of various test methods involving electronic applications.

534.321.9.001.8 **492**

Method of Eliminating Parasitic Waves in Ultrasonic Flaw Testing of Metal Articles.—L. Beaujard. (*C. R. Acad. Sci., Paris*, 13th Oct. 1952, Vol. 235, No. 15, pp. 804–806.) The parasitic echoes are found to be due to surface waves passing directly from transmitter to receiver. They can be practically eliminated by using a c.r.o. with a long-persistence screen.

534.321.9.001.8 : 678.1 **493**

Ultrasonic Techniques in the Rubber Industry.—R. G. Patton & P. Hatfield. (*Electronic Engng*, Nov. 1952, Vol. 24, No. 297, pp. 522–525.) An account of methods of detection of internal air films in rubber products, and measurement of rubber thickness when only one surface is accessible, using ultrasonic waves of frequencies in the range 50–250 kc/s.

538.24.001.8 : 659.24/.25 **494**

The Notched-Disk Memory.—J. Rabinow. (*Elect. Engng, N.Y.*, Aug. 1952, Vol. 71, No. 8, pp. 745–749.) Devices developed at the N.B.S. are described in which information is stored magnetically. Pulses are recorded on both sides of coated Al disks threaded on a horizontal ring surrounding a vertical shaft carrying magnetic heads which can be rotated into association with any desired ring. Data can be recovered in a time of the order of 0·5 sec.

539.16.001.8 **495**

Nucleonics and Industrial Applications.—D. Taylor. (*Electronic Engng*, Nov. 1952, Vol. 24, No. 297, pp. 533–535.)

539.165/.166].001.8 : 531.717.1 **496**

Beta-Particle and Gamma-Ray Thickness Gauges.—M. G. Hammett & H. W. Finch. (*Electronic Engng*, Nov. 1952, Vol. 24, No. 297, pp. 536–539.)

551.508.11 : 621.396.9 **497**

An Improved Fully Electric Radiosonde.—K. Sittel & E. Menzer. (*Bull. Amer. met. Soc.*, Nov. 1950, Vol. 31, No. 9, pp. 341–346.) Details are given of the equipment used for pressure, humidity and temperature measurements, and of the motor-driven switching system used for feeding data to the transmitter.

621.317.083.7 **498**

A Ten-Channel Pulse-Code Telemetering System.—A. J. Bayliss. (*Electronic Engng*, Nov. 1952, Vol. 24, No. 297, pp. 485–489.)

621.318.57 **499**

Speed-Sensing Relay.—J. H. Porter. (*Electronics*, Nov. 1952, Vol. 25, No. 11, pp. 174, 176.) In an arrangement for triggering a circuit at predetermined speeds of a motor, the speed is sampled photoelectrically and the resulting alternating voltage is fed to a thyratron through an adjustable frequency-sensitive network.

621.365.55† **500**

Correlation of Temperature and Electric Fields in a Material undergoing Dielectric Heating.—J. A. M. Lyon & T. J. Dunsheath. (*Proc. nat. Electronics Conf., Chicago*, 1951, Vol. 7, pp. 475–488.) Assuming that the loss factor can be expressed as a second-degree function of temperature and that the thermal conductivity of the material is very small, an expression relating temperature, electric-field strength, and time is derived. The expression was checked by measurements made during the heating of a wedge-shaped plastic sample.

621.38 : 621.791.052 **501**

A Simple Electronic Weld Timer for Spot Welding Machines.—F. Gerspacher. (*Brown Boveri Rev.*, April 1952, Vol. 39, No. 4, pp. 140–142.) Description, with schematic circuit diagram, of equipment using two ignitrons for accurate control of weld-current times for powers up to about 100 kVA and spot welds up to 180/min.

621.38 : 621.791.7 **502**

Electronics in Resistance Welding.—P. Huggins. (*Electronic Engng*, Nov. 1952, Vol. 24, No. 297, pp. 526–529.) Discussion of various types of welding machine and of electronic systems for weld timing control and automatic compensation of mains-voltage fluctuations.

621.38.001.8 : 669–427.4 **503**

Electronic Inspection of Wire Ropes.—(*Electronic Engng*, Nov. 1952, Vol. 24, No. 297, p. 529.) Short note on equipment for inspection of every inch of a wire rope, such as those used in mines, without interruption of service. Faults not detectable by routine visual inspection are easily detected.

621.38.001.8 : 677 **504**

The Applications of Electronics in the Textile Industry.—A. A. Atkins. (*Electronic Engng*, Nov. 1952, Vol. 24, No. 297, pp. 530–532.) Applications in the manufacture and processing of yarn are particularly noted.

621.384.6 : 614.48 : [641 + 615.7 **505**

Electron Beams sterilize Food and Drugs.—E. A. Burrill & A. J. Gale. (*Electronics*, Nov. 1952, Vol. 25, No. 11, pp. 98–101.) Packaged or bulk material is irradiated by a h.v. electron beam which is swept through an 8° arc 200 times/sec. The electrons are accelerated by the voltage of 2 MV produced by a Van de Graaff generator, and emerge from the accelerator tube through a thin Al window.

621.384.611 **506**

Notes on the 225-cm Cyclotron at the Nobel Institute for Physics, Stockholm.—H. Atterling & G. Lindström.

(*Ark. Fys.*, 19th Aug. 1952, Vol. 4, Part 6, pp. 559–563.) Report of the initial performance of the cyclotron previously described by Atterling (2254 of 1951).

621.384.62 **507**

The Linear Electron Accelerator.—D. W. Fry. (*Philips tech. Rev.*, July 1952, Vol. 14, No. 1, pp. 1–12.) A general account, illustrated by reference to the 2-m corrugated-waveguide accelerator at Harwell. By feeding back r.f. power, high electron energies can be obtained with shorter structures.

621.384.62 **508**

A 1·5 MV Accelerator for Heavy Particles with Analyzing Magnet for Use in Nuclear Research.—C. Mileikowsky & R. T. Pauli. (*Ark. Fys.*, 16th Aug. 1952, Vol. 4, Part 4, pp. 287–298.) Detailed description of equipment installed at Stockholm, comprising accelerator tube fed by a cascade generator working under ordinary pressure.

621.384.62 **509**

Multiple-Cavity Linear Electron Accelerator.—B. L. Miller. (*Rev. sci. Instrum.*, Aug. 1952, Vol. 23, No. 8, pp. 401–408.) Description of an accelerator comprising five cylindrical resonators operating in the TM_{010} mode, and producing beams with energies up to 1·4 MeV.

621.385.833 : 537.291 **510**

Paraxial Electron Trajectories in Electrostatic Lenses.—C. Fert. (*J. Phys. Radium*, July/Sept. 1952, Vol. 13, Nos. 7/9, Supplement, pp. 83A–90A.) Description, with examples, of a simplified method of tracing paraxial trajectories by use of transformation matrices or tables characteristic of intervals or surfaces, following a classical optical method.

621.385.833 : 537.291 **511**

A Method of Calculating Trajectories in Electron Optics. Generalization to Homogeneous Linear Differential Equations.—F. Bertein. (*J. Phys. Radium*, July/Sept. 1952, Vol. 13, Nos. 7/9, Supplement, pp. 91A–98A.)

621.387.4 : 621.385.83 **512**

The 6BN6 Gated-Beam Tube as a Fast Coincidence Circuit.—J. Fischer & J. Marshall. (*Rev. sci. Instrum.*, Aug. 1952, Vol. 23, No. 8, pp. 417–420.)

PROPAGATION OF WAVES

621.396.11 **513**

Deformation of Electromagnetic Pulses Propagated in the Ionosphere.—B. N. Gershman. (*Zh. tekh. Fiz.*, Jan. 1952, Vol. 22, No. 1, pp. 101–104.) A formula (2) is quoted determining the waveform of a pulse which has passed through the ionosphere. The deformation experienced by such a pulse has previously been calculated to a first approximation. Corresponding second-approximation formulae are now derived. For the main part of the pulse, the difference between the amplitudes calculated in accordance with the two approximations is not greater than 2%. The more exact formulae give a clearer picture of the phenomena and, in particular, indicate that the pulse becomes asymmetrical.

621.396.11 : 551.510.535 **514**

The Quasi-Transverse (Q.T.) Approximation to Appleton's Magneto-Ionic Equation.—J. D. Whitehead. (*J. atmos. terr. Phys.*, 1952, Vol. 2, No. 6, pp. 361–362.) It is shown that the usually accepted form of Booker's quasi-transverse approximation (3306 of 1935) to Appleton's equation (1933 Abstracts, p. 30) is incorrect; the correct form is given.

621.396.11 : 551.510.535 **515**

A Physical Interpretation of the Corrected Quasi-Transverse Approximation for the Ordinary Wave.—F. Lied. (*J. atmos. terr. Phys.*, 1952, Vol. 2, No. 6, p. 362.) An interpretation of the approximation given in 514 above.

621.396.11.029.51 : 551.510.535 **516**

Theoretical Group Heights of Reflection of 150-kc/s Radio Waves Vertically Incident on the Ionosphere.—N. Davids. (*J. atmos. terr. Phys.*, 1952, Vol. 2, No. 6, pp. 324–336.) The group heights of reflection for 250-μs Gaussian pulses of 150-kc/s radiation are calculated using a wave-theory treatment including coupling, and an ionosphere model of Chapman type. The results obtained by Gibbons & Nertney (137 of 1952) on c.w. are extended by taking account of dispersion, the characteristics of the received pulse being determined by means of a response function developed from a suitable Fourier-Hermite series. The rapid changes of polarization near the lower edge of the E layer (the 'coupling region') give rise to reflection under suitable conditions, i.e. late night hours associated with low f_cE, but since dispersion is slight, group retardation should be almost negligible. At a higher level in the E layer the refractive index for one of the wave components varies rapidly, and time delays are large for models with low f_cE. Results obtained from the theory are in good agreement with observations.

621.396.11.029.51 : 551.510.535 **517**

Wave Solutions, including Coupling, of Ionospherically Reflected Long Radio Waves for a Particular E-Region Model.—J. J. Gibbons & R. J. Nertney. (*J. geophys. Res.*, Sept. 1952, Vol. 57, No. 3, pp. 323–338.) An extension of previous work (137 of 1952), the same ionosphere model being assumed. The method of variation of parameters is used to obtain approximate solutions of the wave equation for the case of coupling of the ordinary and extraordinary waves. The effect of coupling is to cause a wave traversing a coupling region to excite a new wave in the same direction as that of the incident wave, and also a back-scattered wave in the reverse direction. In the case of 150-kc/s waves, the coupling effects occur for electron densities around 300/cm^3, corresponding to the classical reflection level for the ordinary wave. The solutions obtained indicate that the assumed model may be satisfactory as regards group heights and the return of at least two echoes of a single incident pulse, but that for satisfactory explanation of absorption and polarization effects an electronic D region must be assumed below the E region.

621.396.11.029.51 : 551.510.535 **518**

A Method for Obtaining the Wave Solutions of Ionospherically Reflected Long Waves, including All Variables and Their Height Variation.—J. J. Gibbons & R. J. Nertney. (*J. geophys. Res.*, Sept. 1952, Vol. 57, No. 3, pp. 423–426.) Discussion on 137 of 1952.

621.396.11.029.53/.55 : 551.510.535 **519**

The Causes of Excessive Absorption in the Ionosphere on Winter Days.—W. Dieminger. (*J. atmos. terr. Phys.*, 1952, Vol. 2, No. 6, pp. 340–349. In German.) In a previous paper by Dieminger & Hoffmann-Heyden (2317 of 1952) it was suggested that echoes observed on frequencies in the range 1·6–4 Mc/s, due to reflections at heights of 75–100 km, were related to the abnormally high absorption experienced by waves traversing the ionosphere on some days in winter. Further investigations, now reported, confirm this view. The echoes are produced by a partial reflection at a sharp boundary of an ionized region extending down from the E layer to heights of 75–90 km. Solar control is indicated, but no conclusive

explanation is yet available. Echoes produced by reflection at 95 km at night-time are attributed to meteoric-dust ionization.

621.396.11.029.58 : 551.510.535 520

Radio Links covering Very Great Distances.—E. Harnischmacher & K. Rawer. (*C. R. Acad. Sci., Paris*, 6th Oct. 1952, Vol. 235, No. 14, pp. 709–711.) Observations obtained on links with the antipodes using decametre waves indicate lateral deflections due to ionospheric reflections. It seems possible that reflection occurs in a nearly horizontal plane at regions of horizontal ionization gradient at certain times of the day, e.g., around sunrise. An estimate is made of the decrease of received field strength caused by the deflection thus produced. This type of propagation may explain certain observations of reception at frequencies above the m.u.f.

621.396.11.029.62 521

Optical Refraction and U.S.W. Propagation in the Baltic Area in the Spring of 1952.—E. A. Lauter & G. Bartels. (*Z. Met.*, July 1952, Vol. 6, No. 7, pp. 215–220.) An unusual case of anomalous optical refraction observed on 17th April 1952 is discussed in relation to the prevailing weather conditions and radio propagation at a frequency of 90·7 Mc/s over the 180-km path from Copenhagen to Kühlungsborn. Both vertical and horizontal inhomogeneities of the lower atmosphere have an important influence on propagation. High values of received field strength do not always accompany abnormal optical refraction, but were observed throughout the season whenever there was a marked inversion over the Baltic.

621.396.8 : 621.3.018.41(083.74) 522

World-Wide Standard-Frequency Broadcast Reception.—E. L. Hall. (*Tele-Tech*, June & July 1952, Vol. 11, Nos. 6 & 7, pp. 46–48, 99 & 64–65 . . 126.) A report of some thousands of observations during 1950 of the reception of WWV and WWVH signals at places distributed over a large part of the surface of the earth, and of a few observations made in U.S.A. and in Hawaii of the reception of 5-Mc/s and 10-Mc/s signals from station MSF (Rugby, England). Analysis of the available data indicates that (*a*) the 5-Mc/s transmissions are generally useful for shorter distances during daylight and for a few thousand miles at night, (*b*) the 10-Mc/s transmissions are useful for longer distances and do not show the pronounced day-time attenuation noted with 5-Mc/s signals, (*c*) the 15-Mc/s signals are useful for distances from a few hundred to 10 000 miles, day or night. Reception range is affected by changes in sunspot numbers, by season of year, ionosphere disturbances, and local conditions of atmospheric or man-made electrical noise.

621.397.26.029.63 : 621.396.81 523

Broadcasting TV in the U.H.F. Band.—J. Epstein & D. W. Peterson. (*Electronics*, Nov. 1952, Vol. 25, No. 11, pp. 102–109.) An investigation was made of the coverage obtainable using frequencies of 530·25 and 850 Mc/s; the difference between propagation conditions at these frequencies and at 85 Mc/s is emphasized. Values of received field strength calculated from theory are presented for comparison with the observed values, which are lower. Two distance ranges are considered, viz. 1–5 and 5–21 miles respectively. Transmitting aerials with strong vertical directivity were used, the 850-Mc/s aerial being also horizontally directive. Tilting the beam slightly downward was found to increase the received field strength so that the required coverage could be achieved with narrower vertical beam-width. Difficulties involved in making measurements in built-up areas are discussed; in the experiments a $\lambda/2$ dipole aerial with plane reflector was used. Small-aperture receiving aerials should be used to avoid field-distortion effects.

621.397.81 : 621.317.328 : 629.135.4 524

Measuring TV Field Intensities by Helicopter.—Preston. (See 576.)

RECEPTION

621.396.621 525

La Météo assigns First Place to a French Communications Receiver.—(*Electronique, Paris*, July/Aug. 1952, Nos. 68/69, pp. 43–45.) Description of a W/T-R/T receiver covering the range 1·94–30·8 Mc/s in seven wavebands, and selected by the French Meteorological Office as the most robust and most easily demountable.

621.396.621.54 526

Design of Slug-Tuned Superheterodyne Receivers.—P. S. Wessels. (*Electronics*, Nov. 1952, Vol. 25, No. 11, pp. 176 . . 202.) Design procedures are given whereby the r.f. and oscillator coils can be made to tune with a sufficiently constant frequency difference by proper choice of the diameter of the tuning cores. Band coverage and oscillator circuits are discussed.

621.396.621.54 : 621.396.822 527

Second-Detector Signal-to-Noise Improvement.—L. S. Schwartz. (*Proc. nat. Electronics Conf., Chicago*, 1951, Vol. 7, pp. 141–150; *Tele-Tech*, Oct. 1952, Vol. 11, No. 10, pp. 56 . . 107.) Signal and noise levels in each functional division of a superheterodyne receiver are analysed, the discussion being limited to radar types of pulse receiver and to signals not less than the noise, both signal and noise being large enough to cause linear operation of the second detector. Formulae are derived from which the noise figure of the receiver can be calculated, knowing only the signal-noise ratio at the output and the gain and loss parameters of the receiver. The theory is checked by measurements on a pulse receiver.

621.396.622 : 621.396.619.11 528

Synchronous Detection of Amplitude-Modulated Signals.—J. P. Costas. (*Proc. nat. Electronics Conf., Chicago*, 1951, Vol. 7, pp. 121–129; *Tele-Tech*, July 1952, Vol. 11, No. 7, pp. 55–57 . . 119.) The detection of periodic signals in noise by the method of correlation has been shown to give large improvements in signal/noise ratio. If an a.m. carrier wave is to be detected, correlation methods lead to synchronous a.m. detection. Demodulation is performed by generating in the receiver a sinusoidal oscillation with the same frequency and phase as the incoming carrier, and multiplying the incoming signals by the local-oscillator voltage. If in addition a second synchronous detection system is applied, with the oscillator in phase quadrature with the signal, considerable adjacent-channel interference suppression results from proper combination of the in-phase and quadrature detector outputs. Discussion shows that d.s.b. signals, when properly received, are in general less susceptible to adjacent-channel interference or jamming than s.s.b. signals.

621.396.622 : 621.396.822 529

Input versus Output Signal-to-Noise Characteristics of Linear, Parabolic, and Semi-cubical Detectors.—A. H. Schooley & S. F. George. (*Proc. nat. Electronics Conf., Chicago*, 1951, Vol. 7, pp. 151–161; *Tele-Tech*, July 1952, Vol. 11, No. 7, pp. 60–63, 75.)

621.396.622.71.029.64 : 537.562 530

An Ionized-Gas Energy Detector for Microwaves.—H. Burroughs & A. B. Bronwell. (*Proc. nat. Electronics Conf., Chicago*, 1951, Vol. 7, pp. 598–609; *Tele-Tech*, Aug. 1952, Vol. 11, No. 8, pp. 62–63 . . 123.) An ionized-gas diode has been found to serve as an effective

detector or heterodyne mixer of microwave signals. The gas is ionized by application of direct voltage to the diode terminals. When used in a waveguide, operation is independent of the waveguide mode.

621.396.82 : 621.396.619.11/.13 **531**

Interference caused by Interfering Transmitters.—M. Kulp. (*Arch. elekt. Übertragung*, Sept. 1952, Vol. 6, No. 9, pp. 388–389.) Addendum to 2325 and 2886 of 1952. More accurate formulae can now be derived for certain of the cases considered, as a result of exact relations having been found between the Bessel functions involved.

621.396.822 : 519.241.1 **532**

Autocorrelation Function and Power-Density Spectrum of Clipped Thermal Noise. Filtering of Simple Periodic Signals in such Noise.—L. Robin. (*Ann. Télécommun.*, Sept. 1952, Vol. 7, No. 9, pp. 375–387.) Analysis is presented relative to the noise resulting from passage of random noise, with a Gaussian distribution and uniform power-density spectrum in the frequency range considered, through a nonlinear clipping circuit. Two methods of determining the autocorrelation function of the clipped noise voltage have been used, an approximate statistical method due to Ville, and a purely mathematical method based on the characteristic function [2168 and 2169 of 1945 (Rice)]. The latter method is preferred, as it gives the required function in the form of a convergent power series, the successive coefficients being respectively proportional to the square of the error function and of its successive derivatives of odd order. A formula, due to Mehler, on the series of products of Hermite polynomials, enables this series to be replaced by a fairly simple definite integral and finally by the sum of functions which are tabulated or easily calculated numerically. The power-density spectrum is given by the Fourier transform of the correlation function. The spectrum is shown to consist of the limited uniform spectrum existing before clipping, with reduced ordinates, with a superposed continuous spectrum extending to infinity and rapidly decreasing.

The filtering of a periodic rectangular signal plus noise by passage through a correlator is examined by the characteristic-function method. The autocorrelation function is obtained in the form of the sum of convergent power series. Hence in the steady state the autocorrelation function is found to be represented by a periodic succession of isosceles triangles whose height decreases as clipping is increased.

STATIONS AND COMMUNICATION SYSTEMS

061.3 : 621.39 **533**

The Work of the 16th Plenary Assembly of the Comité Consultatif International Téléphonique, Florence, 22nd to 27th October, 1951.—A. Langenberger. (*Tech. Mitt. schweiz. Telegr.-TelephVerw.*, 1st July 1952, Vol. 30, No. 7, pp. 214–225.)

061.3 : [621.396.97.029.62 + 621.397.61.029.62] **534**

European Broadcasting Conference, Stockholm, 1952.—H. Pressler. (*Fernmeldetech. Z.*, Sept. 1952, Vol. 5, No. 9, pp. 417–420.) Report of the proceedings. See also 3560 of 1952 (Stepp).

621.39.001.11 : 519.272 **535**

The Autocorrelation Function from the Ergodic Hypothesis.—R. O'Neill, H. M. Thaxton & S. Cutler. (*Proc. nat. Electronics Conf., Chicago*, 1951, Vol. 7, pp. 74–77.)

621.39.001.11 : 536.758 **536**

Concept of Entropy in the Calculus of Probability.—A. Fromageot. (*Ann. Télécommun.*, Sept. 1952, Vol. 7, No. 9, pp. 388–396.) In order to measure the quantity of information, Shannon has introduced a quantity whose mathematical expression is that of entropy in statistical mechanics. Different types of random phenomena for which an entropy can be defined are here distinguished and their principal properties are indicated. Application is made to the theory of communication in the presence of noise.

621.394.324.001.11 : 519.272 **537**

Application of the Ergodic Hypothesis in Calculating the Autocorrelation Function of Teletype Signals.—S. Cutler, R. O'Neill & H. M. Thaxton. (*Proc. nat. Electronics Conf., Chicago*, 1951, Vol. 7, pp. 78–84.)

621.395.659 : 621.387.032.212 **538**

Some Applications of Cold-Cathode Tubes to Switching Systems.—S. Simon. (*Elect. Commun.*, Sept. 1952, Vol. 29, No. 3, pp. 207–218.) The structure and characteristics of Type-2313 cold-cathode relay tube, and some of its applications to telephone switching, particularly the rotary system, are described.

621.396(43) **539**

Established Radio Services of the West German Post Office.—(*Funk-Technik, Berlin*, Sept. 1952, Vol. 7, No. 18, p. 498.) A detailed list of the short-wave and long-wave transmitters and facilities for oversea telephony, telegraphy and teleprinting, and for radio services within Europe, including diplomatic, news and press services.

621.396.323 : 621.396.82 **540**

Experimental Investigation of the Smallest Separation Permissible between the Frequencies of Two Radiotelegraph Transmissions.—A. Niutta. (*Poste e Telecomunicazioni*, June 1952, Vol. 20, No. 6, pp. 272–277.) The Italcable Co., in collaboration with the Dutch Post Office, have made tests on teletype transmissions, using frequencies around 13 Mc/s. Standard phrases and characters were transmitted by a frequency-shift transmitter; tables are presented of the number of errors recorded at the receiver for different values of the frequency separation and relative strength of a disturbing a.m. (on-off) transmitter. The results indicate that 1 kc/s is the smallest frequency separation permissible when the received field strengths from the two transmitters are about equal. For complete protection of one frequency-shift transmission against another, a separation of 2 kc/s is probably necessary.

621.396.5 **541**

Single-Sideband System for Overseas Telephony.—N. F. Schlaak. (*Electronics*, Nov. 1952, Vol. 25, No. 11, pp. 146–149.) The system described operates in the frequency range 4–23 Mc/s and provides four channels. Peak power output of the transmitter is 4 kW. Improvements with respect to earlier equipment include push-button selection of any of 10 preselected frequencies, use of varistors as modulators, a device to ensure full use of output whatever the number of channels in use, and reduction of out-of-band radiation and interchannel crosstalk. The companion receiver is described briefly.

621.396.5 : 621.396.931 **542**

The Suitability of the 1·6–3-Mc/s and U.S.W. Bands for the Development of the Rhine Radiotelephone Service.—W. Kronjäger & H. Wallor. (*Fernmeldetech. Z.*, July 1952, Vol. 5, No. 7, pp. 301–306.) Experimental work on the system for connecting ships on the Rhine with the public telephone service was begun in 1948, using the 1·6–3-Mc/s band. Reception was good in the daytime, apart from atmospherics in summer, but was spoilt at nights by interference from distant stations on this wave-

band. It was decided in 1950 to go over to the u.s.w. band, and experiments were started to decide the merits of the 2-m, 4-m and 7-m bands. Field-strength measurements in the hilly region between Rüdesheim and Coblentz and around Mannheim are reported. A.m. and f.m. systems were compared, f.m. showing several advantages. Use of the 2-m rather than the 4-m or 7-m bands would offer the advantage that equipment for the harbour radio service could be used.

621.396.619.16 **543**

Delta Modulation, a New Modulation System for Telecommunication.—J. F. Schouten, F. de Jager & J. A. Greefkes. (*Commun. News*, June 1952, Vol. 12, No. 4, pp. 115–124.) See 2603 of 1952.

621.396.621 : 621.316.726 : 621.396.931.029.62 **544**

A V.H.F. Multiband Panoramic Receiver.—E. W. Crompton. (*Electronic Engng*, Nov. 1952, Vol. 24, No. 297, pp. 478–484.) The a.m. system developed for county police and fire services [228 of 1949 (Brinkley)] involves the use of several (usually three) unattended v.h.f. transmitters about 10–30 miles apart, operating on frequencies in the band 90–100 Mc/s with spacings of 7–12 kc/s. A detailed description is given of equipment for monitoring the radiation, modulation and frequency spacing of four such county systems simultaneously. The signals from the different transmitters are displayed in the form of pulses on the screens of two double-beam c.r. tubes. Carrier power determines the pulse amplitude, and the degree of modulation is given approximately by the pulse width. A simple method for determining the frequency separation of any two transmitters is described.

621.396.65 **545**

Result of a Tour of Inspection of Radio Links in the U.S.A.—E. Dietrich. (*Fernmeldetech. Z.*, July 1952, Vol. 5, No. 7, pp. 327–332.) Report of a survey made in October 1951. Station buildings are particularly discussed and illustrations are shown; some of the most modern aerial towers are of steel.

621.396.65 : 621.395.44 **546**

An Experimental Radio-Telephone Link between Eindhoven and Tilburg.—J. M. van Hofweegen. (*Commun. News*, June 1952, Vol. 12, No. 4, pp. 144–152.) Detailed description of the new f.m. transmitter and receiver designed for the 15-channel R/T link between two factories 30 km apart. Operating frequency is about 300 Mc/s, channel bandwidth 4 kc/s, and power delivered to a Yagi aerial 20 W. A.f.c. is applied magnetically to the oscillator coil, which is shunted by a NTC resistor (303 of 1950) ensuring correct operation when the transmitter is cold. Noise figure of the receiver referred to input and detector circuits is about 8.

621.396.65.029.62/.63 **547**

V.H.F. Radio.—E. G. Hamer. (*Wireless World*, Dec. 1952, Vol. 58, No. 12, pp. 519–523.) A review of various systems in use, including mobile and fixed services, both broadcasting and multichannel. The relative merits of f.m. and a.m. in different cases are considered.

621.396.66 : 621.396.97 **548**

B.B.C. New Automatic Unattended-Transmitter Technique.—F. A. Peachey, R. Toombs & C. Gunn-Russell. (*Electronic Engng*, Oct. & Nov. 1952, Vol. 24, Nos. 296 & 297, pp. 446–449 & 490–492.) A description is given of the operating principles of (*a*) equipment providing automatic monitoring of an unattended transmitter over the line linking it to its parent station, (*b*) monitoring equipment for stations with several transmitters operating in parallel, each transmitter being checked by its own self-contained monitor, as in the case of the two-unit 150-kW transmitter at Daventry (2924 of 1952). Details have previously been given [1491 of 1951 (Rantzen et al.)] of the line type of monitor.

SUBSIDIARY APPARATUS

621-526 **549**

Design of Damper-Stabilized Instrument Servomechanisms.—J. F. Koenig. (*Proc. nat. Electronics Conf., Chicago*, 1951, Vol. 7, pp. 24–28.)

621-526 : 621.3.012.8 **550**

A Transient Approach to the Solution of a Linear Servomechanism by an Equivalent Network.—S. P. Tung. (*Proc. nat. Electronics Conf., Chicago*, 1951, Vol. 7, pp. 7–13.)

621-526 : 621.3.016.352 **551**

Stabilization of Variable-Carrier-Frequency Servomechanisms.—K. Schurr. (*Proc. nat. Electronics Conf., Chicago*, 1951, Vol. 7, pp. 14–23.)

621.311.6 : 621.316.722.1 **552**

Highly Stable Power Supply.—G. Cosci & K. Fränz. (*Rev. telegr. Electronica, Buenos Aires*, Aug. 1952, Vol. 40, No. 479, pp. 473–475.) Description of equipment giving voltages adjustable between 200 and 300 V with loads up to 100 mA; the variation of output voltage is of the order of 1 part in 10^4 for line fluctuations of 10%. The d.c. output resistance is 0·14Ω and the residual hum voltage < 0·2 mV. A VR75 valve is used as voltage comparison standard. The feedback circuit includes two pentode stages and a cathode-follower stage comprising two triodes in parallel.

621.311.6.027.7 **553**

High-Voltage Power Supplies.—(*Electronics*, Nov. 1952, Vol. 25, No. 11, pp. 170, 172.) Two units are described: (*a*) an interrupted r.f. oscillator with rectifier-tripler, and (*b*) a continuous r.f. oscillator with rectifier doubler. Both give an output of about 200 μA at 25 kV and both include low-loss transformers with ferroxcube cores. (*a*) is housed in an oil-filled container; (*b*) is larger, and dispenses with oil.

621.316.722.1 **554**

A Variable-Voltage Stabilizer employing a Cold-Cathode Triode.—F. S. Goulding. (*Electronic Engng*, Nov. 1952, Vol. 24, No. 297, pp. 493–497.) A circuit is described in which a cold-cathode gas-filled triode acts as a d.c. amplifier. Such an arrangement has desirable characteristics as a voltage stabilizer in low-current circuits. A portion of the output voltage of a source is compared with a reference voltage, the difference being used to control the current through the parallel-connected stabilizer valve so that the output voltage is maintained at a constant value.

TELEVISION AND PHOTOTELEGRAPHY

621.397.26 **555**

Experimental U.H.F. Broadcast.—R. P. Wakeman. (*Electronics*, Nov. 1952, Vol. 25, No. 11, pp. 168, 170.) Brief account of a schools television broadcast made in April 1952. The video equipment was a standard DuMont dual orthicon camera chain. Signals were beamed on 7 kMc/s from the point of origin to the New York u.h.f. broadcasting transmitter (558 of 1952) 12 miles away. The u.h.f. aerial system comprised two slotted waveguides arranged back to back. Commercial v.h.f. receivers were used with u.h.f. converters; aerials were 12-element broadside arrays with reflectors.

621.397.26.029.63 : 621.396.81 **556**

Broadcasting TV in the U.H.F. Band.—Epstein & Peterson. (See 523.)

621.397.3 **557**

Some Recent Developments in Photo-Telegraphy and Facsimile Transmission.—J. Bell, J. A. B. Davidson & E. T. A. Phillips. (*Proc. Instn elect. Engrs*, Part III, Nov. 1952, Vol. 99, No. 62, pp. 344–359. Discussion, pp. 359–363.) An account of recently produced equipment, including machines for 500-lines/in. scanning and electrochemical receiving and monitoring equipment.

621.397.3 **558**

The Transmission of Pictures by Radio.—A. W. Cole & J. A. Smale. (*Proc. Instn elect. Engrs*, Part III, Nov. 1952, Vol. 99, No. 62, pp. 325–334. Discussion, pp. 359–363.) A review of picture-telegraphy developments since 1842, and particularly of radio methods since the first transatlantic tests in 1924.

621.397.3 : 621.394.9 **559**

A Photo-Telegraph Transmitter-Receiver utilizing Subcarrier Frequency Modulation.—R. O. Carter & L. K. Wheeler. (*Proc. Instn elect. Engrs*, Part III, Nov. 1952, Vol. 99, No. 62, pp. 335–343. Discussion, pp. 359–363.) Description of equipment using the same mechanical and optical system for transmission and reception. Drum speed is controlled by a crystal oscillator.

621.397.5 **560**

The Northern Television Outside Broadcasts.—W. D. Richardson. (*B.B.C. Quart.*, Spring 1952, Vol. 7, No. 1, pp. 55–61.) Description of technical arrangements in connection with the inauguration of the Holme Moss transmitter, October 1951.

621.397.5 : 535.623–624 **561**

Definitions for Colour Television.—(*Electronics*, Nov. 1952, Vol. 25, No. 11, pp. 208 – 236.) Approved working definitions submitted to the U.S. N.T.S.C. in June 1952 are presented.

621.397.5 : 535.88 **562**

Instantaneous Theater Projection Television System.—V. Trad & R. Muniz. (*J. Soc. Mot. Pict. Telev. Engrs*, Aug. 1952, Vol. 59, No. 2, pp. 125–139.) Description, with circuit details, of a dual projection system of the Schmidt type. A simple control box mounted in the cinema projection chamber provides almost instantaneous change-over in case of breakdown of either unit. An automatic brightness-control circuit is included in the equipment. The mechanical design facilitates operation and maintenance.

621.397.5 : 612.84 **563**

The Significance of Adaptation of the Eye for Television Transmission.—P. R. Arendt. (*Fernmeldetech. Z.*, Sept. 1952, Vol. 5, No. 9, pp. 411–416.) Discussion of the characteristics of the human eye as regards its sensitivity to light stimulus, response to changes of intensity, perception of contrast, etc., in relation to the optical characteristics of television systems.

621.397.5 : 621.396.712.2.3 : 061.4 **564**

Exhibition Broadcasting Studios.—G. T. Myers & I. Newbiggin-Watts. (*B.B.C. Quart.*, Autumn 1952, Vol. 7, No. 3, pp. 181–192.) Description of the arrangement and construction of the studio and control room for television broadcasts from the Radio Exhibition, London, 1951.

621.397.6 : 621.396.615.17 **565**

Grey-Scale Generator.—G. E. Hamilton & R. Howite. (*Electronics*, Nov. 1952, Vol. 25, No. 11, pp. 143–145.) A thyratron circuit is described for generating a stepped signal, corresponding to a standard scale of graded greys, for investigating the transfer characteristics of television circuits. The signal includes blanking and synchronizing pulses. With this method of testing, operation conditions are the same as for picture signals, and there is no need to disable clamping circuits. The standard signal may be included on the film, when making photographic records of television, to provide a control.

621.397.61 **566**

Experimental 850-Mc/s TV Transmitter.—G. A. Olive. (*Electronics*, Nov. 1952, Vol. 25, No. 11, pp. 110–115.) Description of the transmitter at station KC2XCY, near Bridgeport, Conn. A grounded-grid Type-6161 forced-air-cooled coaxial triode with single-tuned cavity is used for the final stage, with grid modulation. Neutralizing requirements are analysed in detail. The peak power output of the modulated vision transmitter is 300 W, and the aerial gain is 19·2 db. When running unmodulated the output power is 200 W, the anode-circuit efficiency of the final stage being then about 58%. Phase modulation on the Serrasoid principle is used in the sound transmitter, which operates on 854·5 Mc/s and has a power output of 150 W to an aerial with a gain of 16·2 db. The circuit for preventing relative drift between sound and vision carrier frequencies is described particularly.

621.397.61 : 621.396.619.2 **567**

A Comparison of High-Level with Low-Level Modulation for Television Transmitters.—V. J. Cooper. (*Marconi Rev.*, 3rd Quarter 1952, Vol. 15, No. 106, pp. 118–137.) A detailed study is made of various possible methods of achieving a 50-kW television transmitter, based on the performance to be expected from a representative selection of available valves. It is assumed that the minimum possible bandwidth is provided conforming to the B.B.C. asymmetrical transmission characteristic; this assumption implies that there should be no external response-shaping filters. With low-level modulation the main problem is to achieve adequate coupling and bandwidth in the intervalve circuits; the possibilities of double-tuned and triple-tuned couplings are examined in relation to both 405-line and 625-line standards. While under laboratory conditions the low-level system can show a small saving of initial cost, the high-level system is preferable in general because it is simpler to maintain.

621.397.61 : 621.396.619.2 **568**

Low-Level Modulation.—(*Wireless World*, Dec. 1952, Vol. 58, No. 12, pp. 512–514.) A comparison is made between low-level and high-level modulation systems, with particular reference to the B.B.C. television transmitters at Kirk O'Shotts and Wenvoe on the one hand and Sutton Coldfield and Holme Moss on the other. The low-level system costs less and is more adaptable.

621.397.62 : 621.311.69 **569**

High-Tension Generators for Large-Picture Projection Television.—J. J. P. Valeton. (*Philips tech. Rev.*, July 1952, Vol. 14, No. 1, pp. 21–32.) Four methods are discussed for generating voltages of 5 kV and over. For producing a picture 3 m × 4 m a voltage of 50 kV is required; the method used in this case involves the rectification of a sinusoidal voltage of frequency 20–30 kc/s, generated by an oscillator incorporating a coil with ferroxcube core. With this arrangement the direct voltage is maintained steady from no-load to full-load conditions, and there is a rapid fall when full load is exceeded. The oscillator and rectifier are described; steps are taken to ensure a low internal resistance. Details, with illustrations, are given of two experimental 50-kV generators supplying 0·45 mA and 1·5 mA respectively.

621.397.62 : 621.316.726 : 621.317 570

Evaluating A.F.C. Systems for Television Receivers.—G. Howitt. (*Electronics*, Nov. 1952, Vol. 25, No. 11, pp. 132–135.) Description of measurement techniques and circuits for assessing the performance of a.f.c. systems used in conjunction with horizontal-deflection circuits.

621.397.62 : 621.396.662 571

Performance and Design of a Compact U.H.F. Tuner.—H. F. Rieth. (*Tele-Tech*, Aug. 1952, Vol. 11, No. 8, pp. 42–43 . . 80.) Description of a frequency-converter attachment which uses a shorted transmission line for continuous tuning from 470 to 890 Mc/s. Its associated i.f. amplifier, with 21-db gain, feeds directly into the v.h.f. receiver.

621.397.621 572

Improved Blanking Circuit.—S. Cuker. (*Electronics*, Nov. 1952, Vol. 25, No. 11, pp. 260 . . 264.) With the higher voltages used in large-screen picture tubes, an increase of retrace time is unavoidable, necessitating blanking of the horizontal retrace. To eliminate the so-called 'curtain effect' thereby introduced, the retrace blanking is made proportional to the brightness level. A suitable circuit is shown.

621.397.621 : 621.318.23 573

Fundamentals of the Permanent-Magnet Focusing System for Cathode-Ray Tubes.—K. Jekelius. (*Fernmeldetech. Z.*, July 1952, Vol. 5, No. 7, pp. 320–326.) Formulae are derived from which, in conjunction with measured correction factors, the parameters of simple permanent- and energized-magnet electron lenses can be calculated with good accuracy. To avoid astigmatism in permanent-magnet lenses, attention must be paid to geometrical and magnetic symmetry and care must be taken that the external field is not made asymmetrical by the presence of iron parts.

621.397.621 : 621.318.4 574

Deflector-Coil Construction.—W. T. Cocking. (*Wireless World*, Dec. 1952, Vol. 58, No. 12, pp. 480–486.) Detailed illustrated description of a method based on winding a flat slab coil and bending it to the required shape, using a special winding former and simple bending jig adapted for the production of both line-deflection and frame-deflection coils.

621.397.621.2 : 535.623 575

The 3-Gun Shadow-Mask Color Kinescope.—H. B. Law. (*Elect. Engng, N.Y.*, Aug. 1952, Vol. 71, No. 8, pp. 723–728.) See 844 of 1952.

621.397.81 : 621.317.328 : 629.135.4 576

Measuring TV Field Intensities by Helicopter.—J. G. Preston. (*Tele-Tech*, June 1952, Vol. 11, No. 6, pp. 64–65 . . 114.) Measurements carried out in a helicopter, using a retractable horizontal resonant loop as receiving aerial mounted well below the fuselage, were found very reliable. Reflection and terrain effects which interfered with measurements at ground level were avoided, so that the effect of aerial modifications on the radiation pattern could be quickly and accurately determined.

621.397.828 577

Bus-Bell Interference.—(*Wireless World*, Dec. 1952, Vol. 58, No. 12, p. 511.) Simple methods are indicated for preventing interference with television reception due to operation of the stop-start bell on buses.

621.397.5 578

Television. Book Review—F. Kerkhof & W. Werner. Publishers: Cleaver-Hume Press, London, 475 pp., 50s. (*Wireless Engr*, Dec. 1952, Vol. 29, No. 351, p. 336.) A translation. See 2643 of 1952.

TRANSMISSION

621.396.619.27 : 621.3.011.21 579

The Performance of Rectifier Modulators: Part 1—The Input Impedance of Rectifier Modulators with Frequency-Selective Terminations.—D. G. Tucker. (*Proc. Instn elect. Engrs*, Part III, Nov. 1952, Vol. 99, No. 62, pp. 409–402.) "The calculation of the input impedance appears to be impracticable in the general case, but in special cases where the terminating impedances can be restricted to zero or infinity or to a pure resistance at the various frequencies which can exist in the circuit, and where the resistance-time function of the rectifier can be expanded as a Fourier series independent of the signal frequencies, i.e., controlled solely by the carrier, calculation is possible, and a selection of results is tabulated."

621.396.619.27 : 621.3.011.21 580

The Performance of Rectifier Modulators: Part 2—Carrier-Leak Control in Rectifier Modulators by the use of a D.C. Meter.—D. G. Tucker. (*Proc. Instn elect. Engrs*, Part III, Nov. 1952, Vol. 99, No. 62, pp. 402–404.) Monitoring of carrier leak in a modulator of the shunt type can be effected by means of a d.c. meter measuring the d.c. component of the leak. For very accurate results the back impedance of the rectifiers must be very high or else comparatively well balanced. This method should enable leak voltages of the fundamental carrier frequency to be maintained at a level 40 db below the carrier voltage. The method is not suitable for use with ring modulators.

621.397.61 581

Experimental 850-Mc/s TV Transmitter.—Olive. (See 566.)

621.397.61 : 621.396.619.2 582

A Comparison of High-Level with Low-Level Modulation for Television Transmitters.—Cooper. (See 567.)

621.397.61 : 621.396.619.2 583

Low-Level Modulation.—(See 568.)

VALVES AND THERMIONICS

537.533.8 584

Angular Distribution of Secondary Electrons from Nickel.—J. L. H. Jonker. (*Le Vide*, July/Sept. 1952, Vol. 7, Nos. 40/41, pp. 1230–1238.) See 1769 of 1952.

621.314.7 585

Transistors operate at 300 Mc/s.—G. M. Rose & B. N. Slade. (*Electronics*, Nov. 1952, Vol. 25, No. 11, pp. 116–118.) Point-contact transistors are considered. Operation at higher frequencies can be achieved by reducing the spacing between the emitter and collector electrodes, but limits are set by mechanical difficulties and stability considerations. Instability is due to a positive-feedback effect which can be controlled by suitable choice of Ge resistivity. Oscillations at frequencies up to 302 Mc/s have been achieved with transistors having an electrode spacing of about 0·0005 in.

621.314.7 : 621.396.822 586

Blocking-Layer Interaction and Statistical Fluctuations in Crystals with Three Electrodes (transistrons).—H. F. Mataré. (*J. Phys. Radium*, July/Sept. 1952, Vol. 13, Nos. 7/9, Supplement, pp. 112A–127A.) A brief review is given of the development in America of transistors and in France of transistrons, and measurable parameters are defined which determine the characteristics of transistrons under given operation conditions, such as the short-

circuit stability, the power amplification, and the interaction factor. This factor is simply related to the fraction of the emitter current carried by the holes, which was introduced by Shockley for calculations on filament-type transistors. An equivalent circuit is developed which enables a calculation to be made of the output noise voltage. The physical mechanism which is the cause of the high noise level is discussed. Mathematical theory previously given (2928 of 1952), including derivation of the Einstein-Fokker-Planck equation for the density probability of scleronomic systems in the case of statistical fluctuations, is here repeated.

621.385 : 168.2 587

Electron Tubes for Industry and Research.—C. C. Gee. (*Electronic Engng.*, Nov. 1952, Vol. 24, No. 297, pp. 540–544.) Electron tubes are classified into seven fairly distinct groups, with notes on the principal applications of each of the many sub-groups. The last main group, a miscellaneous one, includes ionization-type vacuum gauges, electron microscopes and particle accelerators.

621.385.029.6 : 621.396.9 588

U.H.F. Valves for 3-cm Radar Equipment.—R. Musson-Genon. (*Le Vide*, July/Sept. 1952, Vol. 7, Nos. 40/41, pp. 1220–1229.) Descriptions are given of suitable magnetrons, reflex klystrons and T.R. and A.T.R. switches. See also 2044 (Musson-Genon et al.), 2066 (Lazzeri) and 2069 (Chantereau et al.), all of 1951.

621.385.5 589

The Communications Valve C3m, a Commercial Amplifier Pentode with Universal Applications.—F. Malsch. (*Fernmeldetech. Z.*, July 1952, Vol. 5, No. 7, pp. 314–318.) This indirectly heated pentode was developed in connection with the German V60 carrier-frequency system, but has found many other telephony applications, being suitable both for a.f. and for r.f. up to 500 kc/s. Construction and characteristics are described; an average life time of 10 000 hours is guaranteed.

621.385.5 590

Proper Use of the Triode-Hexode Valve Type ECH42.—R. de Saint-André. (*TSF et TV*, Sept. 1952, Vol. 28, No. 287, pp. 258–262, 266.) The uses of the valve as a frequency-changer and as a phase inverter are described, with full details of the operating characteristics.

621.387 : 621.316.722.1 591

A Study of the Characteristics of Glow-Discharge Voltage-Regulator Tubes.—F. A. Benson. (*Electronic Engng.*, Sept. & Oct. 1952, Vol. 24, Nos. 295 & 296, pp. 396–401 & 456–460.) Report and discussion of tests carried out on 14 types of voltage-regulator tube, using from 2 to 36 samples of any single type. Detailed studies were made of the variations of striking and running voltages for both short-period and long-period operation, hysteresis effects, voltage jumps, and the effects of temperature, overload currents, vibration, stray magnetic fields, and storage. It is concluded that though modern high-stability types show substantial improvement over earlier designs, glow-discharge tubes are not suitable for use in precision power-supply circuits unless they are specially selected and used under carefully controlled conditions.

621.396.615.141.2 592

A Statistical Approach to the Space-Charge Distribution in a Cut-off Magnetron.—G. Hok. (*J. appl. Phys.*, Sept. 1952, Vol. 23, No. 9, pp. 983–989.) The state of a magnetron with anode voltage below nominal cut-off value is not initially strictly steady, and electron interactions in the interelectrode space produce a drift away from the initial condition. The steady state finally reached depends on the ratio of anode voltage to cut-off voltage. The electron distribution function is complicated, and only a qualitative picture of this distribution is presented.

621.396.615.141.2 593

Mode Interactions in Magnetrons.—R. R. Moats. (*Tele-Tech*, July 1952, Vol. 11, No. 7, pp. 39–41, 88.) A measure of the strength of any oscillation mode is its ability to persist against possible competition from other modes or against the destructive effect of excess anode voltage. The principal factor determining the strength of a mode is the effectiveness of feedback. Van der Pol's theory of nonlinear feedback oscillators is outlined and its bearing on magnetron oscillations is discussed. Experiments on mode interaction and mode transition are described. The results obtained indicate that the essential requirement for quick starting of oscillations under pulse conditions, and for stability with or without the presence of other modes, is the establishment and maintenance of effective electron bunching in the desired mode.

621.396.615.141.2 594

Study of the Magnetron in the Cut-Off Condition: Part 2.—P. Fechner. (*Ann. Radioélect.*, July 1952, Vol. 7, No. 29, pp. 199–220.) Taking account of the static space-charge distribution described in part I (3619 of 1952), the effects of a h.f. e.m. wave on the electrons are analysed. In a multicavity magnetron four resonance frequencies for the electrons in the electron cloud are found possible. One resonance frequency results from an effect of the radial component of the h.f. field, the other three from phenomena due to the tangential component of the field at the mouth of each cavity. Experiments are described which confirm the accuracy of the formulae obtained, and hence verify the theory of the distribution of space-charge density. The method used for observation of the electron distribution in the interelectrode space of the magnetron permits study of the space charge without distortion.

621.396.615.142.2 595

New Pulse Klystron Amplifier for the 960–1215-Mc/s Region.—C. Veronda. (*Elect. Engng, N.Y.*, Aug. 1952, Vol. 71, No. 8, pp. 686–689.) Description of the SAL-39, a three-resonator cascade-amplifier klystron developed for use in air-navigation aids. Beam focusing by space charge is basic to the design. See also 2393 of 1952 (Learned & Veronda).

621.396.615.142.2 596

Construction, Properties and Mode of Operation of Drift Valves (Klystrons), and Problems of their Application.—R. Gebauer & H. Kosmahl. (*Z. angew. Phys.*, July 1952, Vol. 4, No. 7, pp. 267–280.) A comprehensive review. 38 references.

MISCELLANEOUS

44-3 : 621.396 597

Detailed English-French Radio Lexicon.—P. A. Boursault. (*TSF et TV*, Sept. 1952, Vol. 28, No. 287, pp. *Doc. tech.* 1–2.) A first selection of useful English terms (letters A–C) with French equivalent, taken from a radio glossary compiled by the author; to be continued in succeeding issues.

621.39 : 061.3 598

I.R.E. [Australia] **Convention, 1952.**—(*Proc. Instn Radio Engrs, Aust.*, Aug. 1952, Vol. 13, No. 8, pp. 319–329.) Summaries are given of the papers presented.

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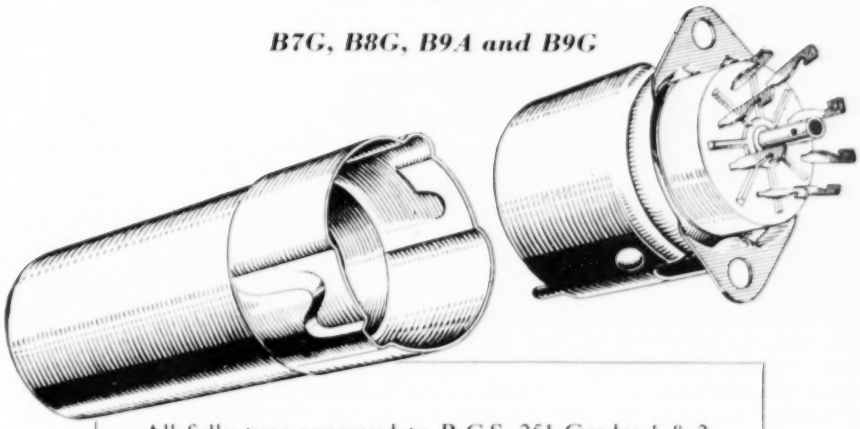

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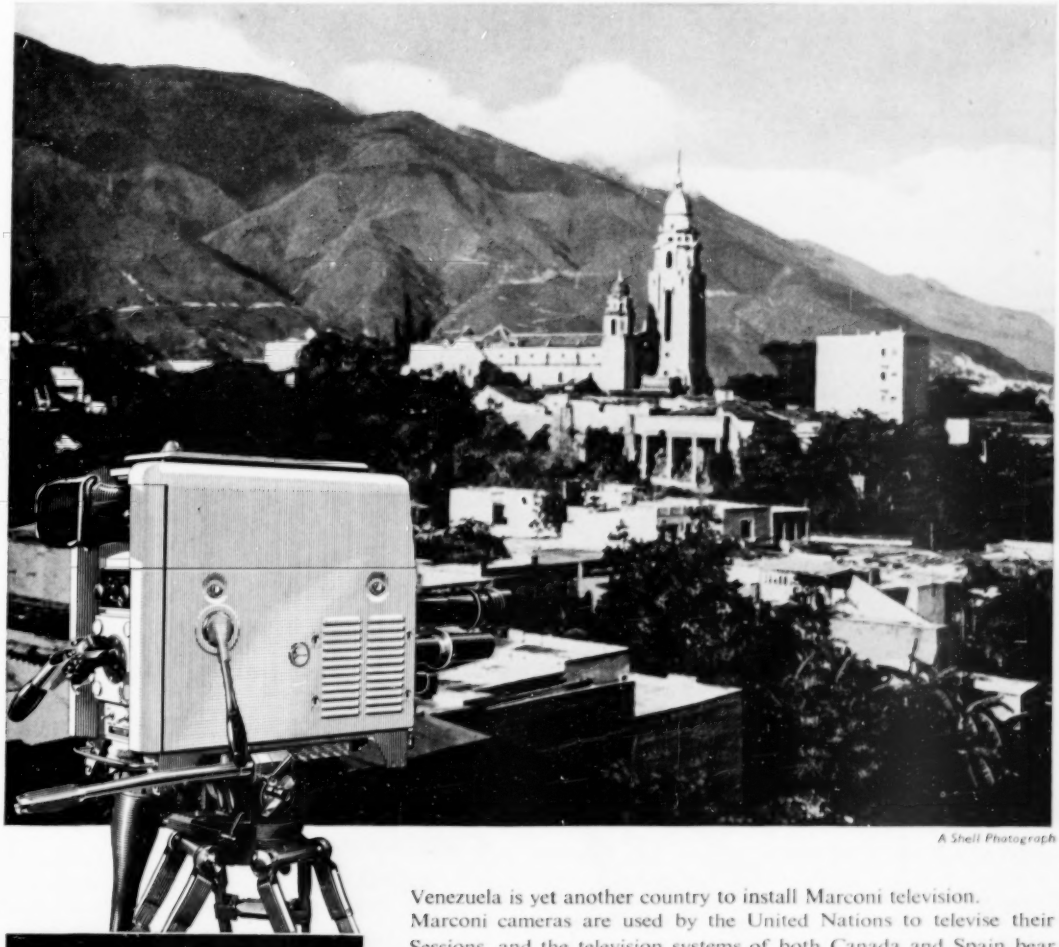

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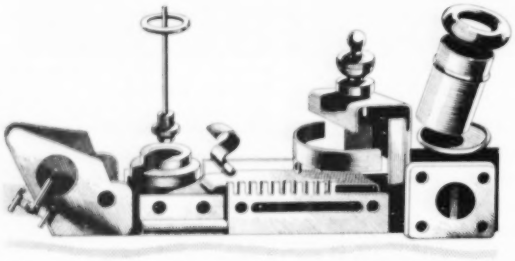

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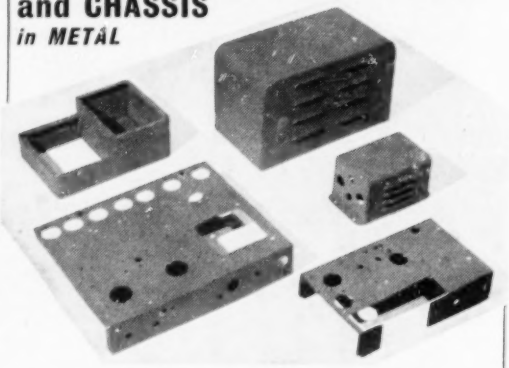

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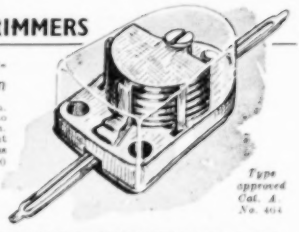

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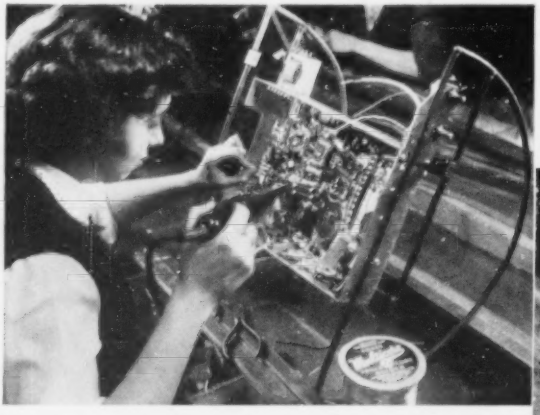
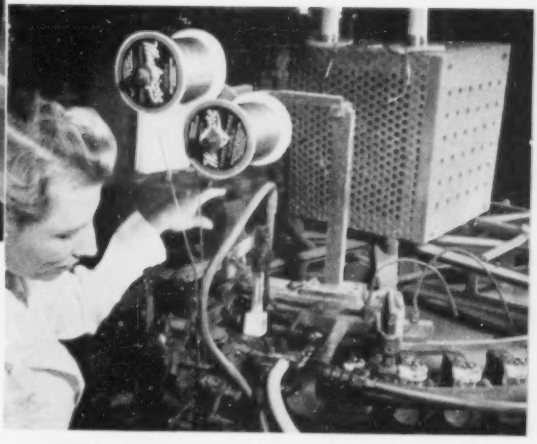
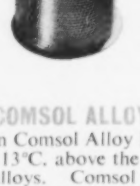




(ABOVE) RADIO AND TELEVISION. *Ersin Multicore Solder is used exclusively by the Ferguson Radio Corporation, Enfield, Middlesex. 60/40 Alloy 16 s.w.g. is shown here being used in the final assembly of the main chassis of the Ferguson 16" Television console 989.*

(RIGHT) ELECTRIC LAMPS. *At the Atlas Lamp Works, Edmonton. Ersin Multicore Solder in 20/80 alloy 16 s.w.g. is used for the soldering of end caps on standard BC electric lamps. This machine is capable of capping and soldering 3,000 lamps per day.*



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TECHNICAL INFORMATION

Laboratory Engineers and Technicians are invited to write for samples of alloys and a copy of "Modern Solders" containing comprehensive technical information and useful tables of melting points.

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